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A quarterly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the Plantations of the Hawaiian Sugar Planters' Association.

In This Issue:

Pre-Harvest Samples:

A timely article on pre-harvest sampling is submitted by William Wolters, of the Oahu Sugar Company, Ltd. He describes in detail the method developed and used by the Oahu Sugar Company. Results for the last three years, showing a very close correlation between the pre-harvest and actual figures, are also given. This article is well worth very careful study.

A Report on the Local Use of Student's Method:

Several of the methods which have been used in Hawaii for arriving at the significance of results from field experiments are discussed by O. H. Lyman. The advantages of Student's Method are pointed out, and examples are given illustrating its use.

Kutsunai's modification of Chauvenet's criterion is considered a satisfactory basis for discarding plots which fluctuate too widely from the means of their series.

Root Pressure and Root Pressure Liquids of the Sugar Cane Plant:

A technique of collecting root pressure liquids from stools of cane growing under field conditions in quantities sufficiently large for chemical analyses is reported. The composition of these liquids is suggested as an approach to the nutritional problems of the cane plant.

The root pressure, as measured by columns of mercury, the heights of which rose at night and fell during the day, was correlated with the percentage of moisture in the soil. The root pressures exhibited by different varieties of cane were correlated with their relative drought resistance, which suggest a method

of determining in advance of field trials the relative drought resistances of new cane varieties.

When tubes filled with a solution were attached to but one cut stalk of a stool, this liquid was drawn into the plant body through the cut stalk. This technique is suggested as a means of studying direct effects of various forms and amounts of liquids and gases, salts, enzymes, vitamins, disinfectants, stimulants, etc., when thus introduced "hypodermically" into stools of growing cane.

Temperature, Rainfall and Sunshine Data on Hawaiian Sugar Plantations:

This article is a compilation of miscellaneous weather data of the plantations in this Territory. It is hoped that the data herein presented will stimulate and facilitate the study of the relation of weather conditions to sugar yields, and thereby enable us to make a more accurate measure of the effect of other influences on yields.

A Rapid Method for the Determination of Potash:

Rapid methods for determinations of plant nutrients in soil extracts, soil percolates and irrigation waters are much needed for agricultural research and control. A colorimetric method for the determination of potash has been adapted to this type of analysis, which is more than four times as rapid as the standard gravimetric method, and which possesses a somewhat greater accuracy than the older method when applied to this class of materials.

Manganese as an Essential Element in the Growth of Sugar Cane:

A brief description of experimental work done elsewhere on the relation of manganese to plant growth is presented, with a discussion of the problems which arise in connection with such experiments. An investigation pursued at this Experiment Station is then described.

It is concluded that manganese is essential to the normal growth of sugar cane. In the complete absence of manganese, symptoms appear which are characteristic of the physiological disease known as Pahala blight.

Root Pressure and Root Pressure Liquids of the Sugar Cane Plant

By D. M. WELLER

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I. INTRODUCTION

Some recent experiments with cane plants growing both in sand cultures and in the field have proven so suggestive and, when reported in the *Monthly Letter* of the Experiment Station, have aroused such general interest that, although in an early stage of their development, the following paper, offered as a progress report, seems to be justified.

The first of these experiments was reported under date of February 25, 1930, as follows:

A young cane plant of the variety P. O. J. 36 growing in sand culture was cut off just above the surface of the sand. By means of rubber tubing, a glass tube of one-inch diameter was attached in an upright position to the stump. A small amount of distilled water was poured into the glass tube to prevent the cut-off end of the stalk from drying. Soon a column of liquid began to rise in the glass tube and after a number of days attained a height of about 15 cm. After 15 days, this column was still rising slowly.

Similar results were obtained when this experiment was repeated with cane of other varieties (H 109, Lahaina, Yellow Caledonia, and D 1135) also growing in sand cultures. This group of experiments is referred to as Series A.

II. PURPOSE AND PLAN

As was mentioned above, the plants of Series A were growing in sand cultures and, when the columns of liquids as the result of root pressure were seen rising in the attached tubes, one could not help wondering how their chemical composition differed from the culture solutions with which the plants were irrigated.

The general purpose of this work became, therefore, (1) to determine whether or not the composition of root pressure liquids obtained from cane plants growing in sand cultures differed from that of the culture solutions with which the plants were irrigated and, if so, in what respect; (2) to determine whether or not the composition of root pressure liquids obtained from plants growing in the field differed from the composition of a true soil solution, or from that of a 1 per cent citric acid extract of the soil in which the plants were growing and, if so, in what respect; and (3) whether or not such comparisons would result in a method for determining the requirements of plant nutrients (soil deficiencies, availabilities, etc.) and water of cane at given ages grown under different field conditions.

III. GENERAL DEVELOPMENT

Following those of Series A the next experiments were confined to plants growing in the field. Glass tubes of one-inch diameter were attached to the stumps of these plants in the same manner as they were attached to those growing in the sand cultures. Plants of the varieties H 109, Yellow Caledonia, D 1135 and P. O. J. 36 were used. This group of experiments was continued over a period of ten days and is referred to as Series B.

Sterile, distilled water was added to each tube until the level of the added water stood at a convenient height above the rubber connection of each tube. This level was established on each glass tube as the zero point. The attachments were made during the period from 9:00 a. m. to 12:00 m. on Saturday. By 12:00 m. of the same day, the column of liquid in the tube attached to the H 109 plant (the first attachment to be made in this series) had risen 18.5 cm. above the zero point. This level was lowered to the zero point by removing 10.5 ml. of the liquid. At 9:00 a. m. on the following Monday, instead of rising above, the liquid had descended below the zero point and water was added to the tube to re-establish the level of the liquid at the zero point again. On each succeeding day of the remainder of the 10-day period it was necessary to re-establish the level of the liquid at the zero point by adding water to the tube.

By 9:00 a. m. on the following Monday, and each succeeding day up to the fifth day, following the attachment of the tube to the Lahaina plant, the level of the liquid in the tube had sunk below the zero point but was re-established by adding water to the tube. On the fifth day, there was a rise of 2.0 cm. of the column

in the tube, which height remained constant throughout the remainder of the 10-day period.

At 9:00 a. m. on Tuesday following the attachment, the height of the liquid in the tube attached to the Yellow Caledonia plant stood at 43.0 cm. above the zero point and was lowered to the zero point by removing 35.5 ml. of the liquid. On each succeeding day of the 10-day period, the level of the liquid was below the zero point but was brought up to the zero point each day by the addition of water.

In the case of both the D 1135 and the Uba plants, no head of liquid above the zero points was obtained but on each day of the 10-day period the level of the water in each tube was found to be below the zero point. Water was added each day to re-establish the level of the water in the tubes at the zero points.

Before describing the behavior of the P. O. J. 36 plant, attention should be directed to the fact that the plants of Series A were constituted of but one stalk. Those of Series B were constituted of from three or four to a dozen stalks and of this number but a single stalk was cut. Because of the underground connections with this stalk, the stalks of the stool left uncut could by "leaf pull" draw away from the cut stalk the liquid which might otherwise collect in its attached tube.

No head of liquid resulted in the case of the P. O. J. 36 attachment but water had to be added each day to the tube because the level of the liquid had always sunk below the zero point. On April 12 instead of an empty glass tube a burette was attached and filled with water to the 50 ml. mark. On April 25, 43.0 ml. had been sucked from the burette into the plant and, on April 26, 50 ml. had been drawn into the stool. From these data, i.e., the fact that liquids may thus be drawn into the plant body, the idea of using this technique as a means of studying the effects of various forms and amounts of liquids and gases when thus introduced directly into stools of growing cane naturally suggested itself. This will be referred to later under the heading of "Suction Feeding."

A. Development of Technique of Collecting Root Pressure Liquids for Chemical Analyses.

Several series of experiments now followed, the object of which was to secure for chemical analyses larger quantities of liquids within a shorter period of time so that the general purpose of this work as stated above could be carried out. Two plants of Yellow Caledonia were selected for the first of these series and are referred to as D-1 and D-2. Instead of permitting a head of liquid to result in attached one-inch tubes as in the preceding experiments, one-fourth inch tubing was connected in such a way as to lead the root pressure liquids off at right angles to the stumps into attached flasks. (See Fig. 1.)

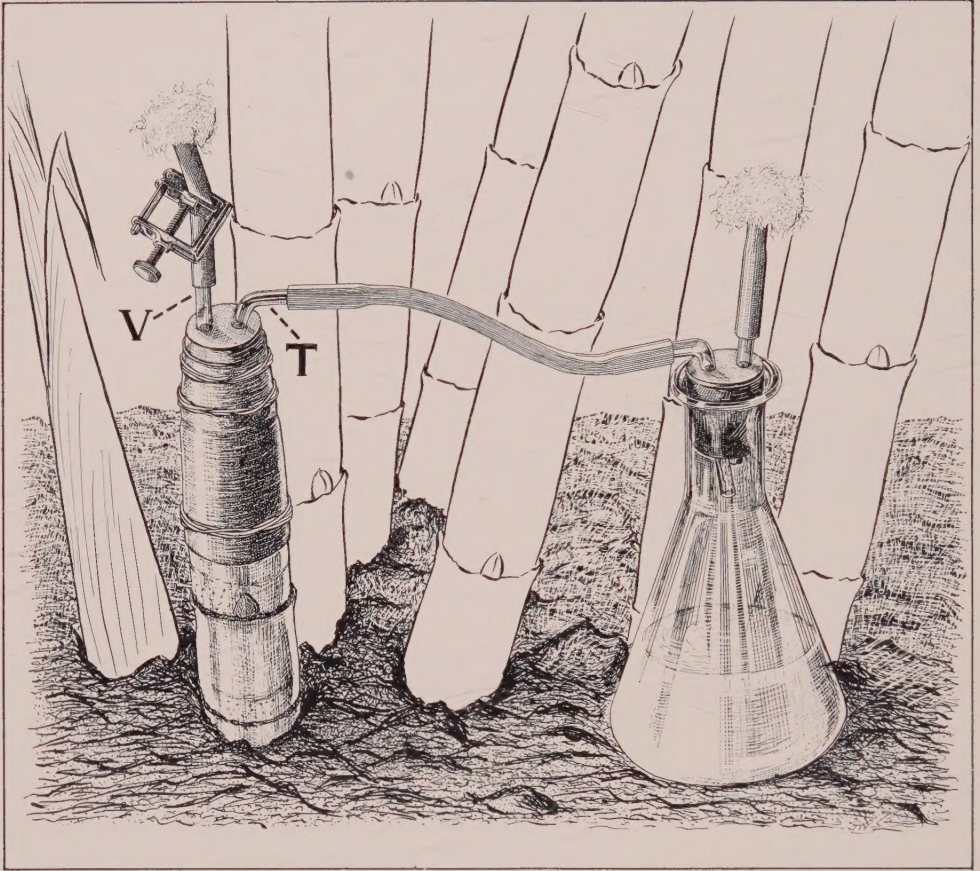


Fig. 1. Showing in detail the method of attaching flasks to the stumps of cane stalks for the purpose of collecting root pressure liquids for chemical analyses. V, vent; T, glass tubing leading to flask.

The flask was thus attached to a secondary stalk of D-1. (Fig. 2, A.) Water was added through the vent (Fig. 1, V) to prevent the cut end from drying. It was observed that this added water, which filled the vent tube and part of the tube leading to the flask, was almost immediately drawn into the plant and, although water was added repeatedly, it was just as often drawn into the plant. While this process was being observed, the idea occurred that the added water could be prevented from being drawn into the plant by decapitating the adjoining primary stalk. The top of the primary stalk was, therefore, struck off at about the 75 cm. level. Almost immediately root pressure liquid began to rise in the vent tube and in the tube leading to the flask and, when the vent tube was closed with the screw compressor clamp, liquid began to follow slowly along the tube leading to the flask (Fig. 1, T). The amount of liquid thus collected in the flask is shown in Table I.

TABLE I

SHOWING THE AMOUNTS OF ROOT PRESSURE LIQUID COLLECTED FROM A
DECAPITATED SECONDARY SHOOT OF A YELLOW CALEDONIA
PLANT AT THE INTERVALS INDICATED

Date	Time	ml. Removed
1930		
April 8.....	1:00 p. m.	(Attachment made)
" 12.....	8:00 a. m.	310.0
" 13.....	8:00 a. m.	280.0
" 15.....	8:00 a. m.	225.0
" 23.....	8:00 a. m.	270.0
Total.....		1,085.0

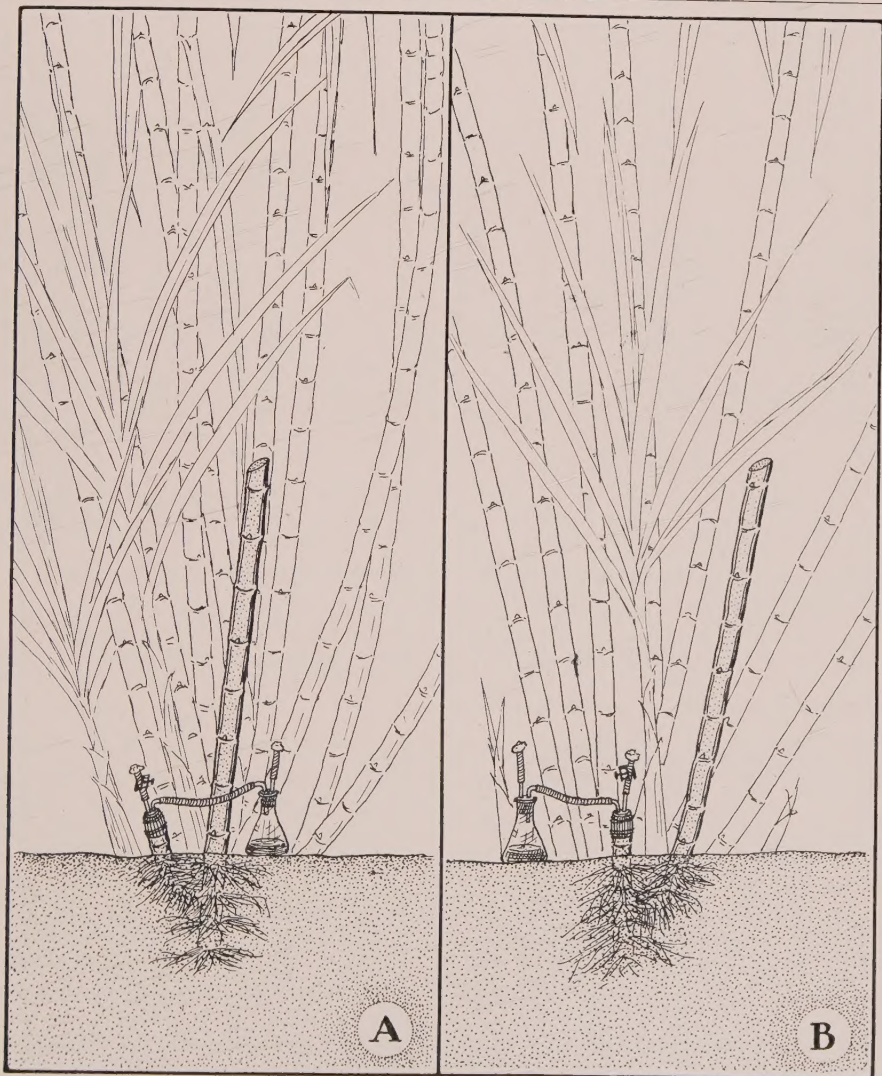


Fig. 2. Showing attachment of flask to a secondary stalk (A), and to a primary stalk (B) of a cane plant. The stalks to which the flasks are attached are cut off at the 15 cm. level while an adjoining stalk of each is cut off at the 75 cm. level.

In the same way attachment was next made to the *primary* stalk of the plant of D-2 (Fig. 2, B) but, even though water was repeatedly added to the tube through the vent, no root pressure liquid rose in the vent tube or the tube leading to the collection flask.

The experiments of Series D were repeated. Attachments were made to primary stalks cut high (75 cm. above the ground level), primary stalks cut low (15 cm. above the ground level), and to secondary stalks also cut high and cut low. These experiments are referred to as Series E-1 to 5, the attachments of which are shown diagrammatically in Fig. 3. The amounts of root pressure liquids collected are shown in Table II.

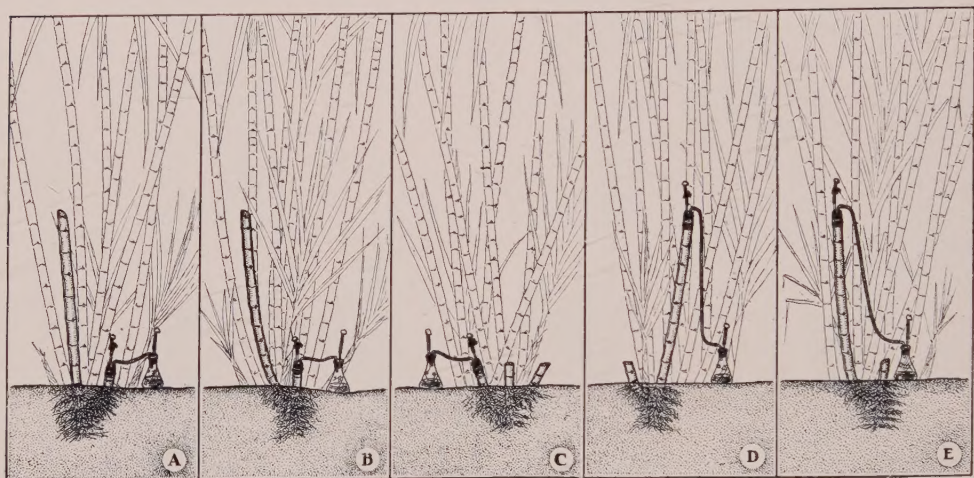


Fig 3. Showing the attachments of Series E-1 (A), E-2 (B), E-3 (C), E-4 (D), and E-5 (E). (Explanation in the text.)

TABLE II

SHOWING THE AMOUNTS OF ROOT PRESSURE LIQUIDS COLLECTED FROM PRIMARY AND SECONDARY STALKS OF YELLOW CALEDONIA CANE WHEN CUT HIGH (75 CM. ABOVE THE GROUND LEVEL) AND CUT LOW (15 CM. ABOVE THE GROUND LEVEL)

Series	Date 1930	Attachment Made To	Height of Stump	Duration	Total Amt. of Root Pressure Liquid	Average ml. per Day
E-1	April 19-May 15	Secondary	15 cm.	26 days	1,308	50.3
E-2	" 23- " 15	Primary	15 cm.	22 days	645	29.3
E-4	" 24- " 15	Primary	75 cm.	21 days	366	17.4
E-5	" 24- " 15	Secondary	75 cm.	21 days	199	9.4
E-3	" 24- " 15	Secondary	15 cm.	21 days	0	0.0

The indications of the data of Table II are that greater amounts of liquid may be obtained when attachments are made to stalks cut low than when made to stalks cut high and that greater amounts may be obtained from secondary stalks than

from primary stalks. These indications will not be discussed here but, in light of additional data, an explanation will be suggested under the discussion. The behavior of E-3, which was not only a secondary stalk, but was also cut low, was the exception rather than the rule, an explanation of which will be offered under the discussion.

In the next series of experiments (F-1 to 10) D 1135 cane was used. Attachments were made to primary and secondary stalks separately and to primary and



Fig. 4. Showing diagrammatically the attachments of Series F-1 to 10. Points of attachment indicated by the letter X. (Explanation in the text.)

secondary stalks simultaneously. When such attachments were made separately, the adjoining primary or secondary stalk was decapitated either "high" or "low." When attachments were made to two stalks of a stool simultaneously, the liquid was conducted by means of a glass Y-tube and rubber hose connections to a common flask. These various combinations are shown diagrammatically in Fig. 4. All attachments were made on May 7 and the amounts of liquids collected determined on May 12, 1930. These data are shown in Table III.

TABLE III

SHOWING AMOUNTS OF ROOT PRESSURE LIQUIDS COLLECTED FROM D 1135 CANE OVER A 5-DAY PERIOD. ATTACHMENTS WERE MADE TO PRIMARY AND SECONDARY STALKS CUT HIGH (75 CM.) AND CUT LOW (15 CM.) SINGLY AND IN COMBINATION. THE ADJOINING STALKS WERE ALSO CUT HIGH OR CUT LOW. (See Fig. 4.)

Series	No. of Attachments	Attachments Made To	Height of Attached Stump	Height of Adjoining Unattached Stump	Total Amt. of Root Pressure Liquid	Average mls. per Stalk
F-8	2	Primary & Secondary	15 cm. 15 cm.	.. ..	161.0 ml.	80.5
F-5	1	Secondary	75 cm.	75	64.0 "	64.0
F-1	1	Secondary	15 cm.	75	61.0 "	61.0
F-7	2	Primary & Secondary	75 cm. 75 cm.	.. ..	109.0 "	54.5
F-6	1	Primary	75 cm.	75	43.0 "	43.0
F-2	1	Primary	15 cm.	75	24.0 "	24.0
F-10	1	Primary	15 cm.	(Uncut)	8.5 "	8.5
F-3	1	Primary	75 cm.	15	4.0 "	4.0
F-9	1	Secondary	15 cm.	(Uncut)	3.0 "	3.0
F-4	1	Secondary	75 cm.	15	1.0 "	1.0

The indications of the data of Table III agree with those of Table II in that more liquid may be obtained from stalks cut low rather than high. There is a further indication that when attachments are made to more than one stalk, the average amount of liquid per stalk exceeds that of either primary or secondary stalks attached singly.

Five stools of H 109 cane were next selected. These are referred to as Series G-1 to 5. Stalks were not cut off and left unattached as in the previous series but attachments were made to all of the stalks which were cut off, as shown diagrammatically in Fig. 5.

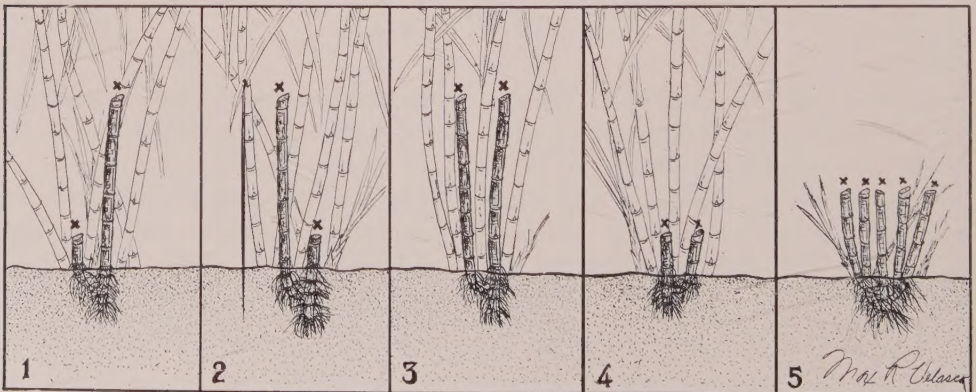


Fig. 5. Showing diagrammatically the attachments of Series G-1 to 5. X indicates points of attachment. (Explanation in the text.)

All attachments were made on May 14 and removed 5 days later. The amounts of root pressure liquids obtained are tabulated in Table IV.

TABLE IV
SHOWING THE AMOUNTS OF ROOT PRESSURE LIQUID OBTAINED FROM H 109
PLANTS IN A PERIOD OF 5 DAYS

Series	Attachments	Attachments Made To	Height of Stump	Total Amt. of Root Pressure Liquid	Average ml. per Stalk
G-5	5	1 Primary 4 Secondaries	15 cm. 15 "	825.0 ml.	165.00
G-2	2	1 Primary 1 Secondary	15 cm. 75 "	122.0 ml.	61.00
G-1	2	1 Primary 1 Secondary	75 cm. 15 "	29.5 ml.	14.75
G-4	2	1 Primary 1 Secondary	15 cm. 15 "	7.5 ml.	3.75
G-3	2	1 Primary 1 Secondary	75 cm. 75 "	5.5 ml.	2.75

It will be noticed that G-5 of this series, the first instance where attachments were made to all of the stalks of a stool, averaged 165 ml. per stalk for the 5-day period. This amount greatly exceeded the average amount per stalk when attachments were made to only two stalks per stool. This method of attachment is pictured in Fig. 6.

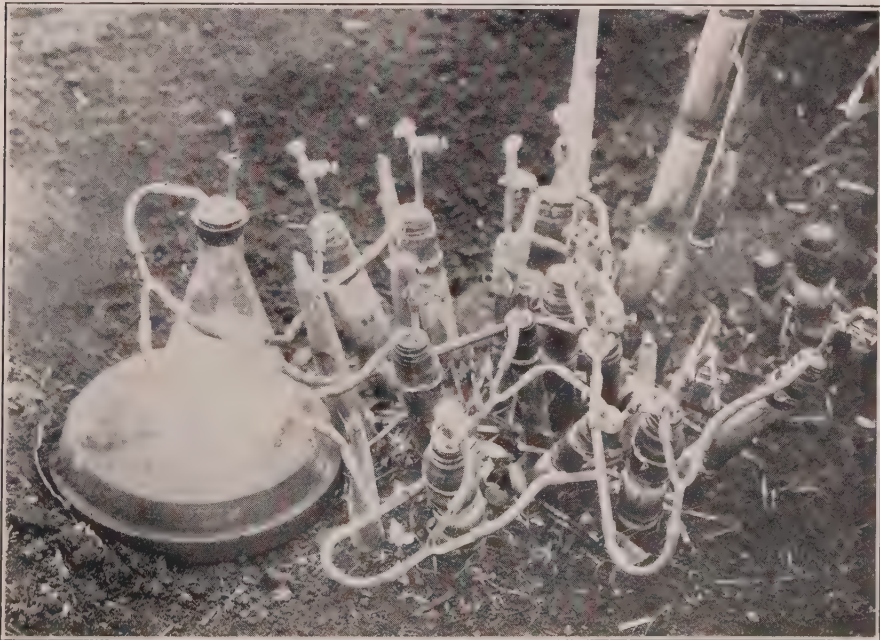


Fig. 6. Method of collecting root pressure liquids from the cane plant for chemical analyses.

The cane used for the experiments of Series B to G was plant cane almost two years old, somewhat neglected, and which was making little growth. The cane used in the next several series of experiments was vigorously growing, 9-months-old cane of the varieties H 109 and P. O. J. 2878. Half of the plantings of each of these two varieties had received applications of fertilizers while the other half had not.

B. Night vs. Day Collections

Two stools of H 109 cane of four stalks each were selected for the experiment of Series I. Each of these two stools was in the fertilized half of the H 109 planting and was composed of two primary and two secondary stalks. Because the technique used in G-5, where for the first time attachments were made to all of the stalks of a stool, had resulted in the collection of the greatest amount of liquid per stalk in a given period of time, the same method was used in this experiment. The stalks of one of these stools (I-1) were cut low (15 cm.) and those of the other (I-2) were cut high (75 cm.). The attachments were made during the afternoon of May 23, 1930. Beginning at 6:00 p. m. on the same day, the amounts of root pressure liquid obtained from each stool during successive 12-hour periods were measured and recorded. By measuring the amounts of liquid obtained at 6:00 a. m. and at 6:00 p. m. the relative amounts of liquids obtained during the day intervals could be compared with those obtained during the night intervals. These data are shown in Table V.

TABLE V
SHOWING THE AMOUNTS OF ROOT PRESSURE LIQUIDS OBTAINED FROM
STOOLS OF FERTILIZED H 109 CANE WHEN ALL STALKS OF THE
STOOLS WERE CUT "LOW" (I-1) AND CUT "HIGH"
(I-2) AT THE INDICATED INTERVALS

1930	Time	Ml. Liquid Removed	
		I-1	I-2
May 23	6:00 p. m.	61.0	16.0
" 24	6:00 a. m.	255.0	151.0
	6:00 p. m.	137.0	96.0
" 25	6:00 a. m.	151.0	108.5
	6:00 p. m.	91.0	84.0
" 26	6:00 a. m.	102.5	107.0
	6:00 p. m.	80.0	74.5
" 27	6:00 a. m.	86.5	79.5
	6:00 p. m.	65.0	59.0
" 28	6:00 a. m.	65.0*	77.0
	6:00 p. m.	57.0	55.0
" 29	6:00 a. m.	81.0	61.5
	6:00 p. m.	56.0	44.0
May 31	6:00 p. m.	238.0	186.0
June 1	6:00 p. m.	118.0	92.0
" 2	6:00 p. m.	110.0	79.0
" 3	6:00 p. m.	100.0	80.0
" 4	6:00 p. m.	108.0	71.0
Total.....		1,962.0	1,521.0

* At the time of this reading a leak had developed in one of the rubber tube connections of I-1.

Here, again, the data of Table V agree with those of Tables II, III and IV in indicating that more liquid may be obtained from stumps cut low than from those cut high, for a total of 1,962.0 ml. of liquid was obtained from I-1 as compared with a total of 1,521.0 ml. from I-2. The data of Table V show also that the amount of liquid collected during the first 5-day period exceeded even that of G-5 (165 ml.) by averaging 287.7 ml. and 222.8 ml. per stalk for I-1 and I-2 respectively.

Another indication of the data of Table V is that a greater quantity of liquid is pumped up by the cane plant at night than during the day. During the first 6 days 741.0 ml. of liquid were obtained from I-1 at night as compared with 486.0 ml. obtained during the day. From the plant cut high (I-2) 584.0 ml. were obtained at night as against 412.5 ml. obtained during the day. This is shown more clearly if, when the data of Table V are arranged as in Table VI, individual as well as total night readings are compared with their companion day readings.

TABLE VI

SHOWING THE AMOUNTS OF ROOT PRESSURE LIQUIDS OBTAINED AT NIGHT
AS COMPARED WITH THE AMOUNTS OBTAINED DURING THE DAY
FROM H 109 CANE CUT LOW (I-1) AND CUT HIGH (I-2)

1930	I-1		I-2	
	Night	Day	Night	Day
May 24	255.0 ml.	137.0 ml.	151.0 ml.	96.0 ml.
" 25	151.0 "	91.0 "	108.0 "	84.0 "
" 26	102.5 "	80.0 "	107.0 "	74.5 "
" 27	86.5 "	65.0 "	79.5 "	59.0 "
" 28	65.0 "	57.0 "	77.0 "	55.0 "
" 29	81.0 "	56.0 "	61.5 "	44.0 "
Total.....	741.0 "	486.0 "	584.0 "	412.5 "

C. Collections from Fertilized vs. Unfertilized Cane

In the next series of experiments (J-1 to 4) two stools of H 109 cane, one fertilized and one unfertilized, and two stools of P. O. J. 2878 cane, one fertilized and one unfertilized, were used. This cane was planted on August 9, 1929, and fertilized on September 28, 1929, at the rate of 1,000 pounds per acre. The fertilizer contained 6 per cent N, 9.5 per cent P_2O_5 and 8.25 per cent K_2O . Attachments were made on May 28, 1930 (eight months after fertilization) and the amounts of root pressure liquids collected from these stools measured at 6:00 a. m. and 6:00 p. m. for 6 successive days, and at 6:00 p. m. for 5 additional days. Both of the H 109 plants were stools of 5 stalks each while the P. O. J. 2878 plants were stools of 6 stalks each. All stalks of each stool were cut "low" and connected to 250 ml. flasks. The amounts of liquids collected from these stools are recorded in Table VII.

TABLE VII

SHOWING THE AMOUNTS OF ROOT PRESSURE LIQUIDS COLLECTED FROM
STOOLS OF FERTILIZED AND UNFERTILIZED H 109 CANE (5 STALKS
EACH) AND STOOLS OF FERTILIZED AND UNFERTILIZED
P. O. J. 2878 CANE (6 STALKS EACH) DURING 12-HOUR
INTERVALS OVER A PERIOD OF 6 DAYS

1930	Time	J-1 (Fertilized H 109)	J-2 (Unfertilized H 109)	J-3 (Fertilized P. O. J. 2878)	J-4 (Unfertilized P. O. J. 2878)
May 28	6:00 p. m.	58.0 ml.(1)	13.0 ml.(1)	11.0 ml.(1)	36.0 ml.(1)
" 29	6:00 a. m.	280.0 " (2)	90.0 "	290.0 " (2)	74.0 "
	6:00 p. m.	150.0 "	56.0 "	146.0 "	97.0 "
" 30	6:00 a. m.	149.0 "	70.0 "	137.0 "	102.0 "
	6:00 p. m.	80.0 "	52.0 "	75.0 " (3)	76.0 "
" 31	6:00 a. m.	88.0 "	70.0 "	108.0 "	88.0 "
	6:00 p. m.	67.5 "	54.0 "	66.0 " (4)	80.0 "
June 1	6:00 a. m.	72.5 "	60.0 "	93.0 "	84.0 "
	6:00 p. m.	56.0 "	44.0 "	69.0 "	76.0 "
" 2	6:00 a. m.	65.0 "	49.0 "	77.0 "	76.0 "
	6:00 p. m.	52.0 "	41.0 "	45.0 "	74.0 "
" 3	6:00 a. m.	61.0 "	46.0 "	60.0 "	72.0 "
	6:00 p. m.	46.0 "	40.0 "	24.0 "	64.0 "
Total.....		1,167.0 "	672.0 "	1,190.0 "	963.0 "

(1) Not included in total.

(2) Flask was overflowing.

(3) Seven young shoots were observed developing from the base of this stool.

(4) The young shoots developing from the base of the stool cut off.

From these data it is seen that more liquid was collected at night than during the day. This was also indicated by the data of Tables V and VI. This can be seen by comparing any night reading with that of the succeeding day reading, or more easily when the data of Table VII are arranged as follows:

	J-1	J-2	J-3	J-4
Night (Total)	715.5 ml.	385.0 ml.	765.0 ml.	496.0 ml.
Day (Total)	451.5 ml.	287.0 ml.	425.0 ml.	467.0 ml.

A still more obvious indication of the data of Table VII is that more liquid may be obtained from fertilized cane than from unfertilized cane. During a period of 6 days a total of 1,167.0 ml. was obtained from the stool of fertilized H 109 as compared with 672.0 ml. from the unfertilized one. A total of 1,190.0 ml. was obtained from the fertilized P. O. J. 2878 as against 963.0 ml. from the unfertilized one. When in Table VII the individual readings for the fertilized stools are compared with those for the unfertilized ones, differences equally striking are seen.

IV. CHEMICAL ANALYSES OF LIQUIDS

It is seen from the data of Table VII that by the technique used in Series J sufficient liquid for chemical analyses may be secured over night, or in twenty-four hours, from a single stool of cane. Stools of H 109 and P. O. J. 2878 cane both fertilized and unfertilized were used in the next series of experiments (L-1 to 4) in the same way as those of Series J-1 to 4. Attachments were made during the afternoon of June 9, 1930, and by the following morning quantities of these liquids sufficiently large for chemical analyses had been collected. Analyses were made of these liquids and also of those from Series I and J, the results of which are shown in Table VIII.

TABLE VIII
SHOWING CHEMICAL ANALYSES OF ROOT PRESSURE LIQUIDS FROM
SERIES I, J AND L.

Results Expressed in Parts Per Million of Original Liquids.

Sample	pH	Loss		Ammonia and				P ₂ O ₅	K ₂ O	SO ₄
		Total Solids	Upon Ignition	Nitrate Nitrogen	Nitrite Nitrogen	Albuminoid Nitrogen	Total Nitrogen			
J-1	5.11	1338	352	Nil	Nil	....	12.3	0.72	83.0	150.0
I-2	3.48	2037	528	“	“	....	5.0	1.05	130.4	70.0
J-1	5.11	2284	684	“	“	....	8.1	0.82	107.0	111.5
J-2	6.91	2242	898	“	“	....	4.2	0.57	105.1	50.5
J-3	4.92	2572	918	“	“	....	11.7	0.72	156.0	111.0
J-4	5.26	2464	1262	“	“	....	13.4	0.97	196.5	71.0
L-1	5.95	....	....	“	“	2.15	4.2	....	....	....
L-2	4.70	....	....	“	“	3.50	3.4	....	....	....
L-3	5.11	....	....	“	“	2.40	1.9	....	....	....
L-4	3.75	....	....	“	“	1.52	3.1	....	....	....

While Table VIII offers insufficient data from which to draw conclusions, several indications are of interest. The first of these is that, while ammonia is present, both nitrate and nitrite nitrogen are absent from these liquids. The liquid from the fertilized H 109 plant (J-1) contained more total solids but showed less "loss upon ignition" than did that from the unfertilized H 109 plant (J-2). The same was true for the liquid from the fertilized and unfertilized P. O. J. 2878 plants (J-3 and J-4 respectively).

From these data it can be seen further that the liquid from the fertilized H 109 plant (J-1) contained more total nitrogen than did that from the unfertilized plant (J-2). The same was true of the liquids collected from the fertilized and the unfertilized H 109 plants of L-1 and L-2 respectively. The reverse was true for the fertilized and the unfertilized P. O. J. 2878 plants, i.e., the liquid from J-3 contained less total nitrogen than that from J-4 and also the liquid from L-3 contained less than that from L-4.

In the J series the liquids from both the fertilized and unfertilized P. O. J. 2878 contained more total nitrogen than did those from both the fertilized and the unfertilized H 109. In the L series the reverse of this was true. When the

total of the figures of the four H 109 plants are compared with that of the P. O. J. 2878 plants it is seen that the total nitrogen for the former was 19.9 parts per million and, for the latter, 30.1 parts per million. Is this an indication that this P. O. J. variety is a relatively heavier nitrogen feeder than H 109?

The liquid from the fertilized H 109 plant (J-1) contained more P_2O_5 and K_2O than did that from the unfertilized plant (J-2). The reverse of this was true for the liquid collected from the P. O. J. 2878 plants (J-3 and J-4).

The liquids from both fertilized and unfertilized P. O. J. 2878 plants contained considerably more K_2O than did both fertilized and unfertilized H 109 plants, an average of 106.05 parts per million for the former vs. 176.26 parts per million for the latter. Is this an indication that the P. O. J. is also a relatively heavier potash feeder than the H 109?

The liquids from the fertilized plants of both varieties of the J series contained more sulphates than those from the plants of both varieties which received no fertilizer.

A. Composition of Root Pressure Liquids vs. Soil Analyses

On August 7, 1930, collection flasks were attached to 5 stools of H 109 cane (Series R-1 to 5). This cane was first ratoons, 16 months old. On July 8 and 9, 1929, it received 90 pounds of nitrogen, 90 pounds of phosphorus, and 60 pounds of potassium per acre. During May 4 to 24, 1930, it received 375 pounds of nitrate of soda per acre in the irrigation water. These flasks were removed on August 9, at which time soil samples (composite samples of four borings) were taken from beneath each stool. On August 19, 5 additional stools were treated in the same way (Series R-11 to 15). The purpose of taking these soil samples was to compare their analyses (1 per cent citric acid soluble) with those of the root pressure liquids. The chemical analyses of both soil samples and root pressure liquids are shown in Table IX.

From the data given in Table IX no conclusions can be drawn. No correlations seem to exist either between the amounts of plant foods in the soil from beneath the stool of cane, as determined by the citric acid method, and those present in the root pressure liquids collected from that stool, or between amounts of plant foods contained in the several specimens.

It is seen that there is less variation in the data for the soil analyses than in those for the analyses of the liquids. This greater variation in the composition of the liquids may be merely an indication of the fineness of the physiological reaction of the plant as compared with a chemical analysis. The differences of analyses of an adequate number of replications of root pressure liquids from one field as compared with those of liquids from another field might be more significant.

1. Prevention of Bacterial Contamination.

If permitted to stand at room temperature, these root pressure liquids soon became "milky" as the result of bacterial contamination. Unless their chemical

TABLE IX

SHOWING THE COMPOSITION OF ROOT PRESSURE LIQUIDS AS COMPARED WITH THE COMPOSITION OF SOIL (1 PER CENT CITRIC ACID SOLUBLE) TAKEN FROM BENEATH THE STOOLS FROM WHICH THE LIQUIDS WERE COLLECTED.

(Results Expressed in Parts Per Million of Original Liquid and of Water-free Soil.)

Series Number	Total Volume ml.	pH	Total Solids	Loss Upon Ignition	Nitrate Nitrogen	Ammonia and Nitrite Nitrogen			Total Nitrogen	P ₂ O ₅		K ₂ O		CaO		SiO ₂	
						Nitrite Nitrogen	Albuminoid Nitrogen			Soil	Liquid	Soil	Liquid	Soil	Liquid	Soil	Liquid
R-1	600	..	1136	304	Nil	Nil	6.6		14.3	49	7.0	220	90	2280	66	1450	404
R-2	704	..	1182	398	“	0.18	2.9		11.8	48	13.2	130	106	2150	58	1010	332
R-3	949	..	1074	358	“	Nil	5.7		13.5	43	24.0	200	75	2360	67	1190	315
R-4	372	..	1127	563	“	“	9.8		18.2	39	17.2	210	71	2560	61	1360	209
R-5	462	..	1139	405	“	“	10.0		18.2	64	26.6	280	108	2480	54	1340	276
R-11	430	..	2184	1385	“	“	10.4		19.3	39	32.5	180	106	2340	81	1300	295
R-12	581	..	2039	1180	“	0.28	27.2		44.0	45	23.4	270	124	2550	58	1380	373
R-13*	9	..	5.26														
R-14†	a. 794	..	4.68	639	“	Nil	12.2		18.2		24.5		86		56		321
	b. 675	..	4.48	620	“	“	8.4		20.2	42	21.8	100	108	2350		1250	
R-15*	132	..	4.85						5.6						53		416

* Insufficient liquid for analysis.

† During the same collection period as for the others, a total of 1469 ml. of liquid was collected from this plant in two fractions.

analyses could be made immediately after collection, it was felt that some method of preventing contamination should be used. In collecting the liquids of Series R (Table IX), therefore, the collection flasks, connections of rubber tubing, Y-tubes, etc., were assembled in the field in such a way as to fit the number and arrangement of stalks of each of the individual stools before the stalks of the stools were cut. The ends of the Gooch tubing, which were to fit over the stumps of the cut stalks, were plugged with cotton. These flasks with their attached connections were then taken to the laboratory, wrapped separately in paper, autoclaved at 15 pounds pressure for 15 minutes, and then returned to the field to be attached as soon as the stalks of each stool were cut. When the stalks of the stool had been cut off immediately prior to attaching the autoclaved connections, the surfaces of the stumps were shaved off smooth with a sharp knife, flushed with a solution of bichloride of mercury and then with sterile, distilled water. The cotton plugs were next pulled from the ends of the Gooch tubing, which were quickly slipped over the ends of the stumps and tightly secured in place with rubber bands.

As a result of the above method the collected liquids were very clear and remained so for a much longer time than when these precautions were not taken.

Because an autoclave was not always at hand, a more convenient method of obtaining similar results was sought by collecting these root pressure liquids in flasks packed in ice, or from which light was excluded, or to which were added disinfectants or preservatives.

The next collections (Series Z) were made in this way. These attachments were made in the usual manner, i.e., the flasks, Y-tubes, and rubber tubing were washed thoroughly and rinsed with distilled water. The connections were assembled in the field at the time the attachments were made to the stools. Light was excluded by turning a light-proof box over the entire stool and its attached flask. Some of the collection flasks were packed in ice during the time the collections were being made. Toluene alone, and with chloroform, was added to some of the collection flasks. The liquids thus collected were brought to the laboratory and permitted to stand at room temperature for several days, after which the degree of their milky appearance as the result of bacterial contamination was recorded. The conditions under which these liquids were collected and their appearance after standing are recorded in Table X.

TABLE X

SHOWING THE CONDITIONS UNDER WHICH THE ROOT PRESSURE LIQUIDS OF SERIES Z WERE COLLECTED AND THE APPEARANCE OF THESE LIQUIDS AFTER STANDING FOR SEVERAL DAYS AT ROOM TEMPERATURE

Series Number	Treatment of Collection Flask During Collection		Preservative Added	Appearance of Liquid After Standing at Room Temperature
	Light	Temperature		
Z- 1	Not excluded	Air	5 ml. toluene	Very clear
Z- 2	" "	Ice	None	Slightly milky
Z- 3	" "	Air	"	Milky
Z- 4	" "	"	"	"
Z- 5	Excluded	"	"	"
Z- 6	"	"	"	"
Z- 7	"	Ice	"	Slightly milky
Z- 8	"	"	5 ml. toluene	Very clear
Z- 9	"	"	5 ml. toluene	" "
Z-10	"	Air	5 ml. chloroform	
Z-11	"	"	5 ml. toluene	" "
Z-12	"	Ice	5 ml. chloroform	

The results of this experiment indicate that the exclusion of light did not affect the degree of cloudiness of these liquids. The reduction of their temperature with ice resulted in some improvement, for the liquids thus collected were only slightly milky. By the use of toluene the best results were obtained. When toluene was added to the collection flasks, whether alone or with chloroform, whether the flask was in the dark or in the light, or whether the temperature was reduced or not, the liquids thus collected were always clear and sparkling. The fact that these liquids were equaled in clearness only by those collected after sterilizing the assembled connections, points to the conclusion that the milkiness of these liquids was due to bacterial contamination and to a disinfecting action of the toluene. When liquid paraffine was substituted for toluene the collected liquids became cloudy.

An analysis of these liquids is shown in Table XI.

TABLE XI

SHOWING IN PARTS PER MILLION THE COMPOSITION OF ROOT PRESSURE LIQUIDS OF SERIES Z

Series Number	Total Volume	pH Value	Nitrate Nitrogen	Nitrite Nitrogen	Ammonia Nitrogen	Albuminoid Nitrogen	Nitrogen in		
							Total Nitrogen	Entire Sample	P ₂ O ₅ , Grams
Z- 1	1015	4.67	None	None	6.0	23.3	61.3	.0623	107
Z- 2	415	4.45	"	"	8.0	27.3	51.0	.0212	47
Z- 4	480	5.31	"	"	5.8	20.5	44.8	.0215	22
Z- 5	385	6.04	"	"	1.1	16.0	40.8	.0157	118
Z- 7	388	4.73	25 approx.	5.0	10.0	28.0	56.6	.0219	27
Z- 8	600	4.80	None	None	10.0	42.0	87.9	.0527	107
Z-10	375	4.75	"	"	7.4	23.0	52.7	.0198	35
Z-11	500	5.26	40 approx.	"	2.8	17.2	44.5	.0222	15
Z-12	425	4.60	40 approx.	"	6.6	15.8	51.8	.0220	33

Note:—Nos. 3, 6, and 9, duplicates of Nos. 4, 5, and 12 respectively, were not analyzed.

The next series of collections (AK-1 to 9) were made from three adjacent stools in the same line of each of three plots of cane, which on June 8, 1930, had received fertilizer as follows:

Collection No.	Fertilizer	Lbs. per Acre
AK-1 to 3	Sodium nitrate	1500
AK-4 to 6	Superphosphate	1500
AK-7 to 9	Potassium sulphate	6000

On February 26, 1931, all three of these plots received nitrogen at the rate of 100 (approximately) pounds per acre in the form of ammonium sulphate. The cane was planted on June 8, 1930, and the attachments were made on March 10, 1931. The first application of fertilizer was mixed with the soil in the bottom of the furrow immediately before the cane was planted.

The compositions of these liquids are shown in Table XII.

TABLE XII
SHOWING IN PARTS PER MILLION THE COMPOSITION OF THE ROOT PRESSURE LIQUIDS OF SERIES AK-1 to 9

Series Number	pH Values	Volatile Matter	Ash	Total Solids	S	U	G	A	R	N	I	T	R	O	G	E	N	Total Nitrogen	P ₂ O ₅	K ₂ O	CaO	SiO ₂
					Sucrose	Reducing Sugar				Nitrate Nitrogen	Nitrite Nitrogen	Ammonia Nitrogen										
AK-1	4.65	2164	1350	3514	440	200		640		None	None		31		30		170		33	210	84	577
AK-2	4.64	2308	1258	3566	470	220		690		"	"		36		31		188		46	251	90	546
AK-3	4.58	2960	1264	4224	510	260		770		"	"		50		85		237		32	237	91	554
<i>Average</i>	<i>4.62</i>	<i>2477</i>	<i>1291</i>	<i>3768</i>	<i>473</i>	<i>236</i>		<i>700</i>		"	"		<i>39</i>		<i>48</i>		<i>198</i>		<i>37</i>	<i>232</i>	<i>88</i>	<i>559</i>
AK-4	4.70	3550	1068	4618	710	420		1130		"	"		46		97		247		57	216	84	491
AK-5	4.79	3086	1078	4164	650	330		980		"	"		47		98		236		33	152	84	505
AK-6	5.00	3082	1202	4284	820	320		1140		"	"		30		54		155		37	159	84	592
<i>Average</i>	<i>4.83</i>	<i>3239</i>	<i>1116</i>	<i>4355</i>	<i>720</i>	<i>350</i>		<i>1083</i>		"	"		<i>41</i>		<i>83</i>		<i>212</i>		<i>42</i>	<i>175</i>	<i>84</i>	<i>529</i>
AK-7	4.78	3912	1196	5108	1160	270		1430		0.11	"		39		70		232		38	234	66	512
AK-8	4.67	3031	1126	4157	760	290		1050		None	"		36		67		187		42	195	74	509
AK-9	4.72	3160	1094	4254	790	320		1110		"	"		30		66		188		34	202	64	491
<i>Average</i>	<i>4.72</i>	<i>3367</i>	<i>1139</i>	<i>4506</i>	<i>900</i>	<i>290</i>		<i>1196</i>		<i>0.04</i>	"		<i>35</i>		<i>67</i>		<i>202</i>		<i>38</i>	<i>210</i>	<i>68</i>	<i>504</i>
<i>Average of AK-1 to 9</i>	<i>4.72</i>	<i>3028</i>	<i>1182</i>	<i>4209</i>	<i>701</i>	<i>292</i>		<i>993</i>		<i>0.004</i>	"		<i>38</i>		<i>66</i>		<i>204</i>		<i>39</i>	<i>206</i>	<i>80</i>	<i>531</i>

Here again nitrates were notably absent, a trace being found in but one instance. Ammonia and albuminoid nitrogen were present. In some instances the variation of pH values, volatile matter, total solids, sugars, salts, etc., was remarkably slight while in others it was greater. How the variations in these data would compare with those in data of soil analyses, or how they would correlate with growth, or with amounts of sugar, cannot be said. The lack of such data renders an interpretation of the data of Table XII difficult.

Further comment will be made on these data under the discussion but, of course, it goes without saying that determinations of a sufficiently large number of replications should be made to make differences in the data significant.

V. ROOT PRESSURE AS MEASURED BY MERCURY COLUMNS

When open tubes six feet high were connected to stumps of cane stalks growing in the field, columns of liquid pumped up by root pressure, rose in them and overflowed from their tops and, when these 6-foot tubes were extended to a length of more than 10 feet, liquid, supported by root pressure, still rose in them and overflowed from their tops.

In the next series of experiments (Series P-1 to 6) mercury columns (manometers) were, therefore, attached to stools of the following varieties of cane: H 109, Lahaina, Yellow Caledonia, D 1135, Uba and P. O. J. 36 (Fig. 7).

The heights of each of these mercury columns were recorded every three hours throughout the day and night for a period of 21 days. In some instances, columns of mercury 138 cm. (1.9 atm.) high resulted. The height of such mercury columns is equivalent to that of water columns of more than 60 feet.

The readings for four of these plants are presented in graphic form in Figs. 8, 9, 10, and 11.

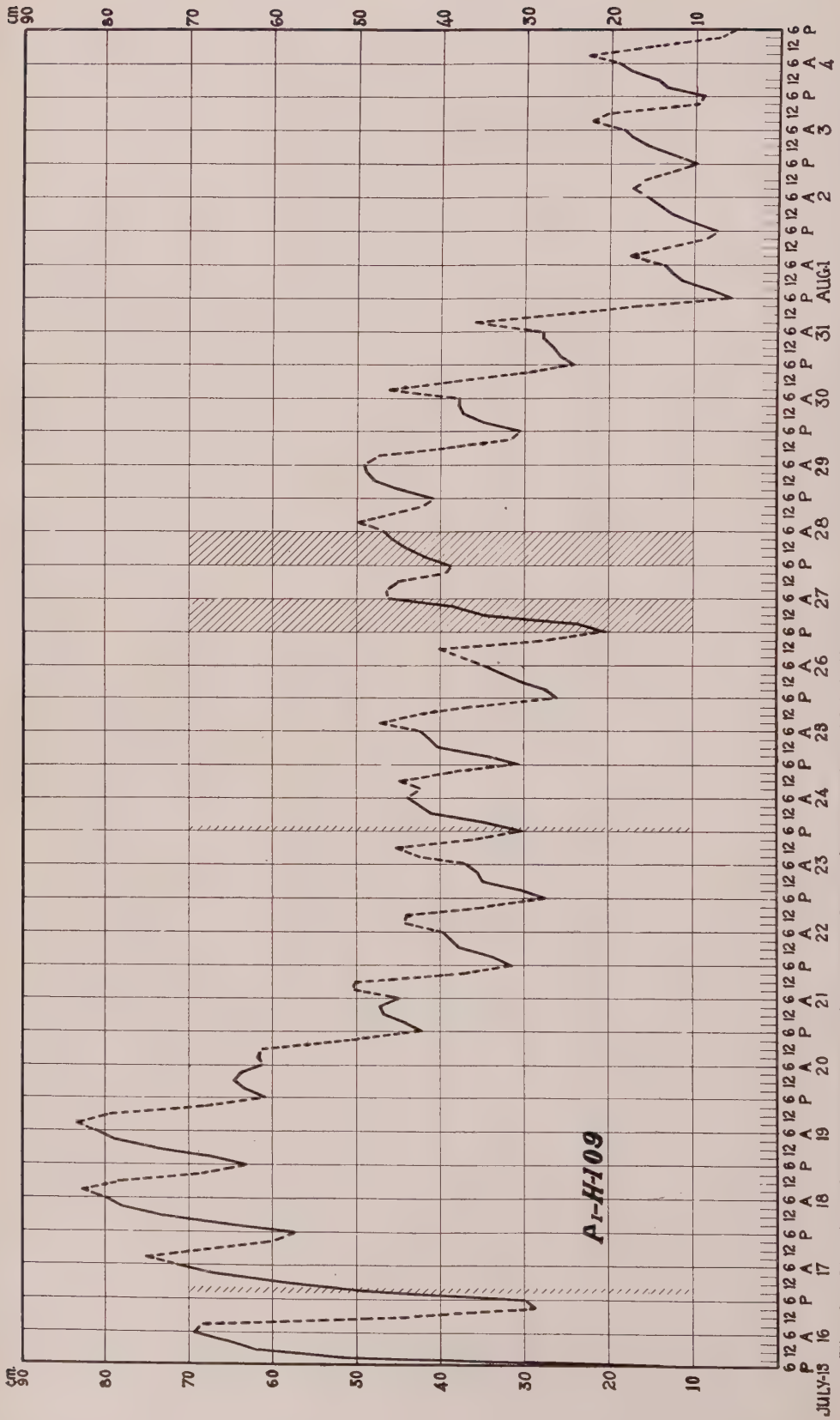
The readings presented in the graphs of Figs. 8, 9, 10 and 11 were taken simultaneously. The cane plants were of the same age, received the same amounts of irrigation water, and in every respect had received identical treatment. Weather data, including readings of maximum and minimum thermometers, wet and dry bulb thermometers, atmometer and rain gauge, were recorded.

In the curves of Figs. 8, 9, 10 and 11, there are several indications which seem to be significant. The first of these is that the root pressure rises at night and falls during the day. The highest pressure point occurred at about 9:00 a. m. and the lowest pressure point at about 3:00 p. m. This correlates with the data as recorded above (Tables V, VI and VII), which show that from the same stool of cane a greater amount of liquid was obtainable during the night than during the day; i.e., the greater quantity of liquid obtained during the night was the result of the increased night pressure.

A second indication is that irrigations resulted in increased pressure. The plants of this series received four irrigations during the 21-day period. The first two of these irrigations occurred on July 16 and 23 at 9:00 p. m. and 6:00 p. m., respectively. These two irrigations were made by running water into the cane rows at the rate of one inch per acre. Each of the other two irrigations was begun at 6:00 p. m. on July 26 and 27, respectively, and continued for a 12-hour period.



Fig. 7. Showing method of measuring the root pressure of cane plants by use of mercury columns. The connections with the manometer were bound with friction tape and copper wire. Rubber stoppers were, in the same manner, bound onto the cut ends of the stalks of the stool not attached to the manometer. Frequently these rubber stoppers were blown off in spite of their bindings.



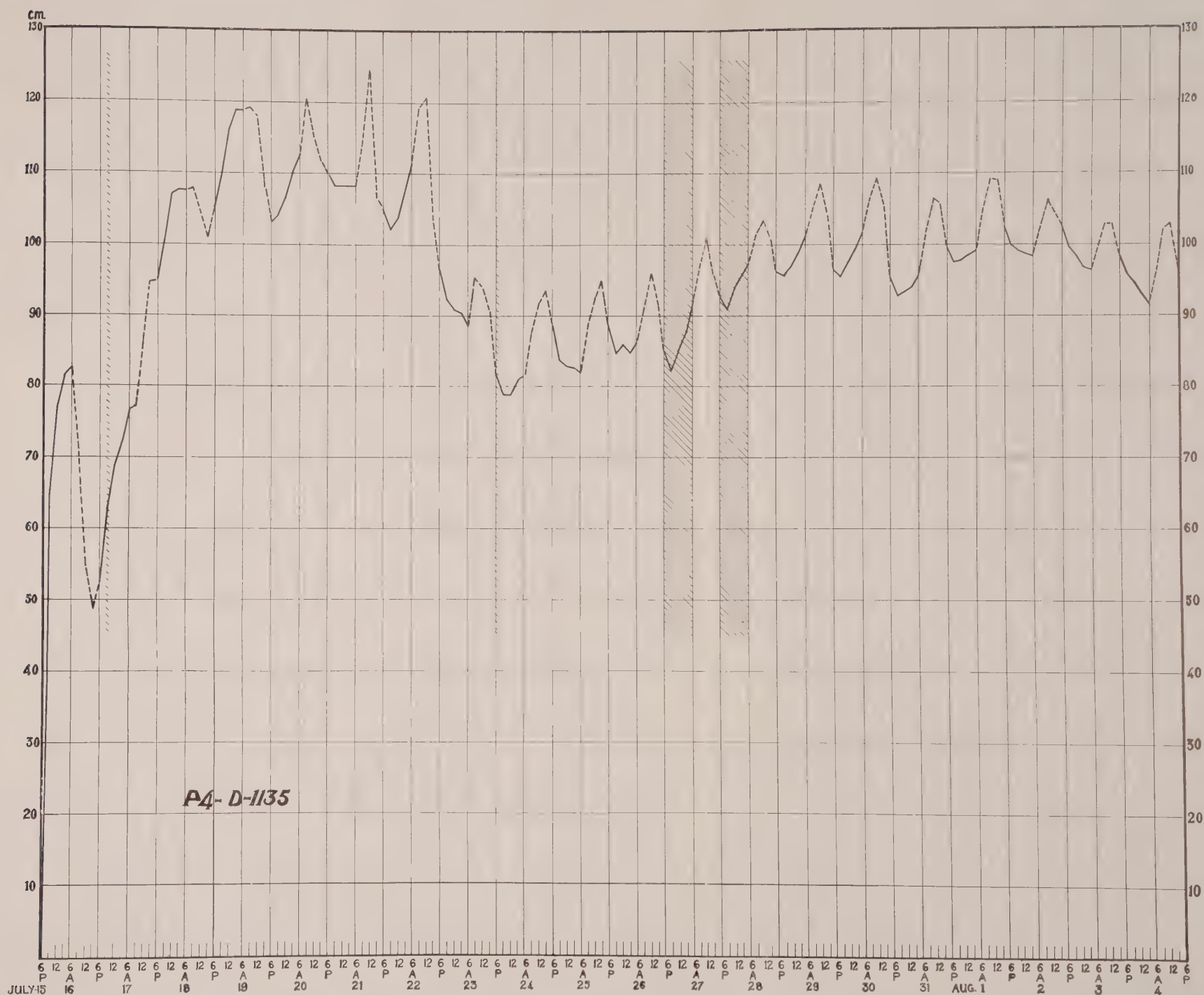


Fig. 10. Showing the root pressure of a cane plant of the variety D 1135 (Series P-4). Record made simultaneously with those of the II 109 and Yellow Caledonia plants recorded in Figs. 8 and 9, respectively.

These latter irrigations were made by the use of lawn sprinklers at a rate which would, during the 12-hour period, somewhat approximate the same amount of water as was applied in the first two irrigations. These irrigations are indicated in Figs. 8, 9, 10 and 11 by cross hatching.

The recorded weather data show that during the 21-day period the rainfall was little more than a "trace" so that the effects of the irrigations on the recorded root pressures were not obscured by water from another source.

It is seen from the graphs of Figs. 8, 9, 10 and 11 that, following the first irrigation on July 16, there was an increase of pressure for each of the four varieties. This first irrigation was purposely withheld until the pressure had passed the first high-pressure point at 9:00 a. m. and was building up again after the low-pressure point at 3:00 p. m. on the day following the attachments.

Following the irrigation of July 23 less increase of pressure was seen than following the first one. This second irrigation was withheld until the pressure had somewhat subsided but, perhaps, this lack of response indicates that water was withheld too long.

Following the 12-hour irrigations by lawn sprinklers definite responses were seen for the H 109, the Yellow Caledonia and the D 1135. It may be interesting to note that, while the amounts of water used in these latter irrigations were no greater than those of the first two, the prolongation of the irrigations resulted in a significant response even after the second irrigation had failed to do so.

When water was withheld long enough the mercury columns of the manometers gradually descended to and crossed the zero point, thus registering negative pressure. As much as —54 cm. of mercury have thus been registered by a plant growing in the field (Fig. 12).

A still more significant indication may be seen by a comparison of the graphs of Figs. 8 to 11. Because of the bearing it may have on varietal variation in respect to drought resistance, this indication, if consistent for a large enough number of plants of each of these varieties to be established as fact, will be of the first importance.

It is seen from the graphs (Figs. 8 to 11) that, as compared with those of the Yellow Caledonia, D 1135 and Uba plants, the pressure for the H 109 plant throughout the 21-day period was considerably lower. The maximum pressure attained by the H 109 plant was 83.4 cm. at 9:00 a. m. on July 19. At 6:00 p. m. on the last day of the 21-day period this pressure had dropped to 5.7 cm. As compared with that of the other three varieties, not only was the maximum pressure of the H 109 plant lower but the pressure finally dropped to a lower point when irrigations were withheld.

Throughout the 21-day period the pressure of the Yellow Caledonia plant was consistently higher than that of the H 109 plant. A maximum pressure of 110.9 cm. was attained at 9:00 a. m. on July 20, which at 6:00 p. m. on the last day of the 21-day period had dropped to 36.0 cm. As compared with those of the H 109 plant greater responses to the irrigations were seen.

The pressure of the D 1135 plant was not only higher throughout the 21-day period than that of the H 109 plant but exceeded that of the Yellow Caledonia plant as well. At 12:00 m. on July 21 a pressure of 124.5 cm. was attained,

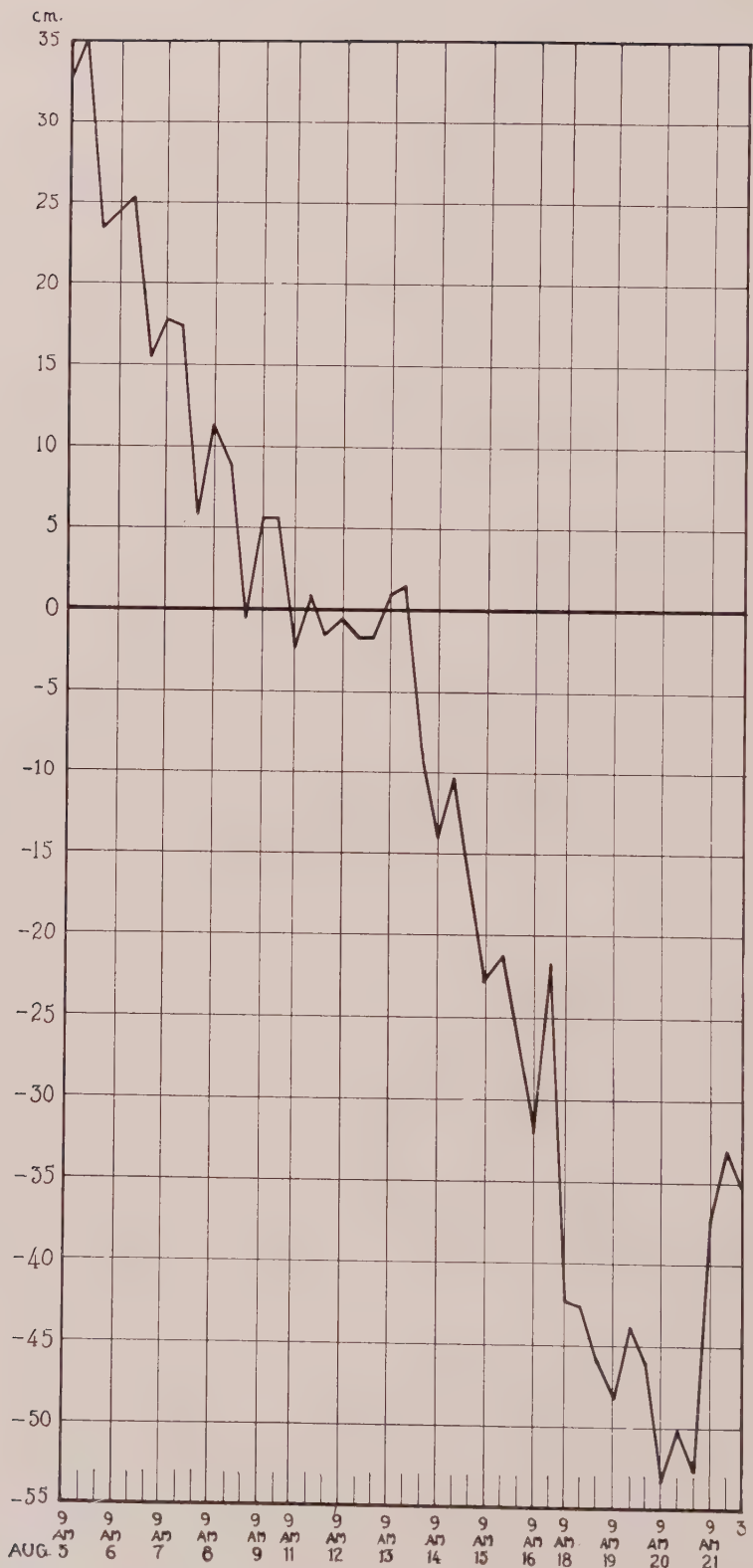


Fig. 12. Showing that when water was withheld from a cane plant (Fig. 9), the mercury column measuring its root pressure descended to, crossed and descended 53.5 cm. below the zero point, thus registering negative root pressure. Readings recorded at 9:00 a.m., 12 m., and 3:00 p.m. only for these dates.



Fig. 13. Showing method of studying direct effects of various forms and amounts of liquids and gases, plant foods, enzymes, vitamins, disinfectants, stimulants, etc., when thus introduced "hypodermically" into stools of growing cane.

which at 6:00 p. m. on August 4 had dropped to 96.4 cm. The responses of this D 1135 plant to irrigation were even more pronounced than were those of the Yellow Caledonia plant.

In the case of the Uba plant we see exhibited the highest pressure of the four plants. At 12:00 m. on July 23 a pressure of 138.8 cm. of mercury was attained and virtually maintained throughout the remainder of the 21-day period. This

height of mercury is equal to a pressure of 1.8 atmosphere, or 26 pounds per square inch, and is equivalent to a column of water 60 feet high.

In the graphs of Figs. 8 to 11 it is seen that there is an indication of a direct correlation between the root pressure of these varieties and their drought resistance.

VI. "SUCTION FEEDING"

Another phase of this work was suggested when a tube filled with a solution was attached to but one cut stalk of a stool and all of the other stalks of the stool were left growing. Because of the underground connections with this stalk, the stalks of the stool left uncut could, as the result of "leaf pull," draw away from the cut stalk the liquid which might otherwise collect in the attached tubes. No head of liquid resulted in the case of such attachments but water had to be added each day to the tube because the level of the liquid had always sunk below an established zero point. Burettes were attached instead of glass tubing and filled with water. After several hours these burettes were empty. (Fig. 13.)

The idea of using this technique as a means of studying the effects of various forms and amounts of liquids and gases, salts, enzymes, vitamins, disinfectants, stimulants, etc., when introduced directly into stools of growing cane naturally suggested itself.

While this injection method has not yet been developed, several experiments in which it was used might be suggestive.

Four solutions of nitrate of soda containing 10, 100, 250, and 500 p.p.m. of nitrogen were used. Two stools of H 109 cane were "injected" with each of these solutions. The burette was attached to the primary stalk of each stool of cane and kept filled for 5 days, after which time the amount of the solutions drawn into each plant was determined.

At the same time four solutions of ammonium sulphate containing the same number of p.p.m. of nitrogen as the four solutions of nitrate of soda were used to inject eight other stools of H 109 cane (two stools with each solution).

This H 109 was five months old, plant cane. It had received no fertilizer whatsoever and was of a very yellow color.

The average amounts of these liquids taken in by each of these stools are shown in Table XIII.

TABLE XIII

SHOWING THE AMOUNTS OF NITROGEN IN GRAMS TAKEN IN BY STOOLS OF FIVE MONTHS OLD H 109 CANE IN A 5-DAY PERIOD BY THE "SUCTION-FEEDING" METHOD FROM SOLUTIONS OF NITRATE OF SODA AND AMMONIUM SULPHATE

Solution	p.p.m. Nitrogen in Solution	pH of Solution	Ml. Solution Injected	Grams Nitrogen Injected
Nitrate Soda	10	5.7	139.0	0.00139
" "	100	5.7	285.0	0.02850
" "	250	5.9	269.5	0.06737
" "	500	6.5	234.5	0.11725
Ammonium Sulphate	10	5.9	80.0	0.00080
" "	100	5.7	76.0	0.00760
" "	250	5.8	30.0	0.00750
" "	500	5.8	76.5	0.03825

From these data it is seen that more nitrogen was taken in in the form of nitrate of soda than in the form of ammonium sulphate. There seemed to be no correlation between the amount of solution taken in and the pH of the solution. In several days after the injections these plants began to show a greener color than the plants in adjacent rows which had not been injected. After several weeks these plants, especially those which had received the greater amounts of nitrogen in the form of nitrate of soda, were of a decided green color and of a larger size as contrasted with the untreated plants.

VII. DISCUSSION

The phenomenon of the exudation of liquid as the result of root pressure, such as has been described in the above experiments, is common to many plants. Priestley and Wormall (6) state that: "Wieler, (7), in 1893, gave a list of 126 species of 93 genera drawn from Filices, Gymnosperms, Monocotyledons and Dicotyledons, reported by previous workers on what seemed to him unexceptional grounds; from his own observations he added another 58 species from 47 genera of vascular plants, including *Equisitum*."

The cause of this phenomenon, i.e., the mechanism of root pressure, is not fully understood although much has been written about it (2), (4), (5), (and literature cited).

Priestley and Wormall (6) also state: "The chemical nature of the exudates frequently obtained in considerable quantity from the root system of a plant is a subject of considerable importance in relation to many problems of plant physiology, and it is a matter for surprise that more definite data are not available in the literature."

If the composition of the root pressure liquid of a plant can be interpreted as an indication of what has been absorbed by the plant from the soil in which it is growing, an index can be had of what is *available* to the plant from that soil and there will at once be at hand a better method of approaching the nutritional problems of that plant.

Despite their general use, certain objections are raised to chemical methods whereby the amounts of plant foods in an extract of a soil are determined. These extracts may be made by any one of a number of chemicals such as citric acid, hydrochloric acid, acetic acid, etc. The principal objection to such methods is the interpreting of the amounts of plant foods so extracted as an index of their *availability* to the plant.

Objections can be had to these methods also because the soil is usually taken from some particular horizon, the first foot, for example. Whatever correspondence exists between this distribution of the roots and the distribution of their feeding surfaces, it is certain that root pressure liquids are absorbed through these feeding surfaces wherever they are in contact with the soil as a result of the natural distribution of the root system in the soil. The lateral spread and depth of such a root system varies, of course, with the variety and age of cane, character of soil, etc., but no system of soil sampling could possibly be so representative as this natural root distribution. In connection with such methods as those

of Mitscherlich, Neubauer, Winogradsky, etc., the question always arises as to the agreement of the plant foods required by the indicator plant with those of the plant under consideration. Some object to the size of the artificial containers used by these methods.

In the use of root pressure liquids these objections, at least, would be eliminated because the very plant under consideration is being used in its natural environment, i.e., the cane plant growing under normal conditions in the cane field.

It should at least be proved, therefore, whether or not the composition of root pressure liquids collected from the cane plant growing under normal conditions offers a more satisfactory method of determining the requirements or deficiencies of plant nutrients of the cane plant.

A. Technique of Collection

It was apparent that the first requisite for accomplishing the objective of the present research was the development of a method of collecting root pressure liquids in amounts large enough for chemical analyses. A technique was finally arrived at of simply cutting off all of the stalks of a stool and, by means of Y-tubes and rubber hose connections, collecting the liquid from the total number of stalks of the stool.

It was demonstrated that more liquid was collected at night than during the day (Tables V and VII), the explanation of which was found later in the experiments on root pressure which demonstrated a rising pressure at night and a falling pressure during the day. This, of course, does not explain why the root pressure was higher at night than during the day but indicates that the amount of liquid collected during the night was greater than that collected during the day simply because of the increased night pressure.

In the earlier experiments, especially the ones preceding those of Series G, where but one stalk of a stool was cut, it will be remembered that sometimes liquid, as the result of root pressure, could be obtained while at other times it could not. More often water, which had been added to the attachment, was drawn into the stool of cane. This is interesting because its explanation may be found in an indicated "balance," or ratio, between the totals of the complementary forces of root pressure and leaf pull.

A possible explanation of the apparent irregularity in the behavior of these earlier experiments may be suggested in that, when but one stalk of a stool was cut, liquid was collected as the result of root pressure, in relation to the leaf pull, being relatively higher; if the leaf pull, in relation to the root pressure, was relatively higher, negative, or suction pressure resulted. When two stalks of a stool were cut, the average amount of liquid collected per stalk per unit of time was greater than when but one was used because the ratio of these two forces was upset still further in favor of the root pressure. As the number of stalks cut per stool was increased, the amount of liquid collected per stalk per unit of time was increased.

Also, depending upon the amounts of moisture in air and soil, the water content of the cells of the plant may be lowered. The difference between this lower amount and the total amount of water a cell is capable of absorbing is known as the

"saturation deficit."* The amount of the saturation deficit depends upon how much the transpiration from the leaves was in excess of the supply of water from the roots. Saturation deficit, then, either separately, or in relation to leaf pull, may also play a part in the above explanation. Certainly as the number of stalks cut per stool was increased, the saturation deficit was decreased.

What differences in the composition of liquids collected from stools of cane with all of the stalks cut as compared with the composition of liquids from stools with one or more stalks left growing was not determined.

From the graphs of Figs. 8 to 11 it is seen that, on successive days after the manometers were attached, the root pressure of the stool of cane gradually decreased. The data of Tables V and VII correlate with these curves in that, on successive days after the collection flasks were attached, the amounts of liquids collected diminished. This correlation explains why, when only one stalk of a stool was cut, liquid was sometimes collected for a day or so and then water had to be added to bring the level of the liquid up to the established zero point.

In the data of Table VII is seen a rather definite indication that larger amounts of liquids may be collected from plants which have been fertilized than from plants which have not. It would be interesting to determine whether this larger amount was due simply to an increased root mass, as the result of the fertilization, to a stimulation of physiological function, or to both.

It was seen that greater amounts of liquids were collected from stools of cane with the stalks cut "low" than from stools of cane cut "high." In the experiments of Series I-1 and I-2, for example, 1962.0 ml. of liquid were collected from the stool with the stalks cut "low" as compared with 1521.0 ml. from the stool with the stalks cut "high," a difference of 441.0 ml. How much of this difference was due simply to a difference of hydrostatic pressure as a result of the stalks of I-2 being 60 cm. higher than those of I-1, and how much was due to the fact that this liquid was absorbed by the cells of the cane stalks, is no doubt capable of determination.

B. Chemical Analyses of Liquids

When the data of the analyses of these root pressure liquids are examined one sees certain clear-cut indications. From the data of Tables VIII, IX, XI, and XII, it is seen that nitrate nitrogen and nitrite nitrogen are practically nil in these liquids. This fact explains, no doubt, why Hoffer's (3) test for nitrate nitrogen made by applying diphenylamine to the tissues between the nodes of freshly cut corn stalks was always negative when applied to cane. It would be interesting to apply this test here in Hawaii both to cane and to corn plants growing in the same soil heavily fertilized with nitrogen and also to compare the composition of the root pressure liquids collected from both the cane and the corn plants.

The absence of these two forms of nitrogen is interesting also in connection with eye spot disease because it was once thought that the degree of severity of an attack of eye spot was due to the presence of nitrate nitrogen in the tissues of the plant. Because the severity of an attack of eye spot can effectively be con-

* The author is indebted to Dr. Chas. A. Shull of the University of Chicago for the expression "saturation deficit."

trolled by withholding applications of a fertilizer containing nitrogen for several months preceding the eye spot season, the question arises as to whether the severity of the attack is due to the form, or to the amount of the nitrogen contained in the tissues of the plant, or whether it is due to the conditions of the tissues due to rapid growth as a result of the fertilization.

In Tables XI and XII it is seen that the albuminoid nitrogen exceeds the ammonia nitrogen by several times. The only exception to this was in the case of AK-1 to 2 (Table XI) where these liquids were collected only 12 days after an application of 100 pounds of nitrogen per acre in the form of ammonium sulphate. Here the ammonia nitrogen slightly exceeds the albuminoid nitrogen and the ratio of ammonia nitrogen to albuminoid nitrogen is considerably less for the average of the three plants (AK-1 to 3) as compared with the rest of the plants (AK-4 to 9), which received phosphorus and potassium along with the nitrogen.

In the AK series the amounts of total nitrogen contained in the liquids from the first plot (AK-1 to 3) would be expected to be greater than the amounts contained in the liquids from the other two plots because it had had a larger application of nitrogen (having received NaNO_3 at the rate of 1500 pounds per acre on June 8, 1930, and ammonium sulphate at the rate of 448 pounds per acre on February 29, 1931). This, however, was not the case; the greatest amount of total nitrogen having been taken up by the plot which had received the application of phosphorus in addition to the application of nitrogen. Also, the amount of total nitrogen taken up by the plot which had received an application of potassium in addition to the nitrogen application was greater than that taken up by the plot which had received two applications of nitrogen. At first these data seem contrary to what might be expected but, perhaps, the story they may have to tell requires interpretation. It may be possible that more nitrogen was taken up in the second and third plots because the addition of a second salt (phosphorus to the second plot—AK-4 to 6—and potassium to the third plot—AK-7 to 9) resulted in greater growth and a greater uptake of whatever was present in the soil as a result of amounts of plant foods being available in more nearly optimum ratios. If this be true, the addition of any single salt above a certain amount would for the time being, at least, be wasted. Better economy would be the "salvaging" of this additional amount (either at once or later in the plants' development) with applications of other plant foods which would make it available.

In the case of the second plot, which was the only plot receiving an application of phosphoric acid, the liquids showed the highest amount of phosphoric acid. In the case of the third plot, which was the only plot to receive potash, the amount of potassium present in the liquids was less than in those from the plots which had received the nitrogen. Such facts as these are difficult to understand.

The amounts of lime and silica taken up by the individual plants in all the plots were remarkably uniform. The amounts of silica taken up in the plot which had received the nitrogen application were highest. This agrees with work done by Ayres (1), who showed that there was a correlation between the uptake of silica and the amount of nitrogen applied.

When the amounts of N, P, and K in these liquids from different fields are

compared, greater differences are seen between fields than between individual stools in the same field. This is apparent when the averages of these elements in all specimens collected are arranged as follows:

Place	Series	No. of Collec- tions	Age of Cane, Months	Number Months After Fertilization	p. p. m.		
					N	P ₂ O ₅	K ₂ O
Pathology Plot	I, J, L	10	9	8	6.73	0.80	129.66
Oahu Sugar Co., Field 55	R	10	16	{ 13 (N, P, K) } { 2.5 (N) }	18.33	21.13	97.11
Experiment Station Grounds	Z	10	8		23.65	56.77	
Waipio Substation, Field 27	AK	9	9	{ 9 (N, P, K) } { 12 (days) (N) }	204.44	39.11	206.22

Because the results of these analyses have been so varied, attempts have been made to standardize a method whereby the significance of the analyses of these root pressure liquids would be made apparent. These attempts were made in sand cultures in which plants were grown with high phosphorus vs. low phosphorus, all other elements of the culture solution remaining the same.

So far these attempts have not netted amounts of liquids as large as desirable for chemical analyses but attempts to increase the amounts of these collections are being continued.

It is planned to compare amounts of various elements, or ratios of elements, taken up by different varieties of cane plants grown in culture solutions containing low amounts vs. high amounts of, or various ratios of, the elements in question. These amounts and ratios can then be compared with the growth of the plants, with the amounts of sugar in these root pressure liquids, and with the amounts of sugar produced by each individual plant.

C. Carbon-Nitrogen Ratios

When the ratio of the total nitrogen to total sugar is studied in the data of Table XII some very suggestive correlations are seen. They are shown in the following table:

Series Number	Total Nitrogen	Total Sugar	Ratio	Fertilizer
AK—1	170	640	1:3.7	NN
AK—2	188	690	1:3.6	"
AK—3	237	770	1:3.2	"
AK—4	247	1130	1:4.5	PN
AK—5	236	980	1:4.1	"
AK—6	155	1140	1:7.3	"
AK—7	232	1430	1:6.1	KN
AK—8	187	1050	1:5.6	"
AK—9	188	1110	1:5.9	"

From these data it is seen that the ratio of nitrogen to sugar is greater in the liquids from the plants which had received both phosphorus and nitrogen than from the plants which received only nitrogen; and in those liquids from the plants which had received potassium and nitrogen, it was the highest of all. These data suggest a possible approach to the study of cane ripening and juice quality.

D. Night vs. Day Pressure

The question as to why greater root pressure was manifested by cane plants at night than during the day cannot easily be explained. At first it was surmised that during the day greater evaporation from the surface of the soil or, that during the day, the transpiration from adjacent plants whose roots were interlaced with those of the cut stool, was responsible for this difference. But stools of cane which were isolated in concrete pots and which had developed from single eyes exhibited the same differences of day and night pressure. Plants in sand cultures, in which very little difference of day and night temperature existed, behaved in the same way. If differences of day and night temperature could be responsible for these differences of day and night pressure, the low pressure would be expected to exist at night and the high during the day. But the very reverse of this exists. Stools of cane covered with light-proof boxes also manifested these day and night differences.

With the data in hand the only suggestion that can be made is that it is the manifestation of a plant habit persisting even after the rhythmical stimulus has been removed and that this stimulus is associated with the force of "leaf pull" caused by rhythmical day vs. night transpiration, or with light and darkness.

In Hawaii, the H 109 is a variety of cane which requires irrigation for successful culture. It is thought of as an "irrigated" cane in contrast with those varieties which, because they do well under unirrigated conditions, are termed "dry land" canes. The term dry land cane used in this respect is apt to be misleading because these canes are grown under conditions varying, according to season, from heavy rainfall to drought. All do better under irrigated conditions but with irrigations H 109 will excel them. Under dry conditions they will excel H 109. Yellow Caledonia, D 1135, and Uba are varieties of these dry land canes exhibiting different degrees of drought resistance. Yellow Caledonia, while requiring more water than D 1135, is thought of as being more drought resistant than H 109, D 1135 more drought resistant than Yellow Caledonia, and Uba as the most drought resistant of all.

E. "Suction Feeding."

The method of "Suction Feeding" offers a technique for studying the effects of various forms and amounts of liquids and gases, salts, disinfectants, stimulants, etc., when introduced directly into the stool of growing cane. By attaching tubes of varying lengths, or by elevating reservoirs to different heights, different hydrostatic pressures may be secured for forcing such liquids into the stools.

What would be the effect on the susceptibility of a stool of cane to eye spot, for instance, into which had been injected varying forms and amounts of nitrogen? The susceptibility of cane to eye spot is reputed to be due to the presence of *nitrates* in the leaves and yet the chemical analyses of these root pressure liquids

show nitrate nitrogen to be totally absent. Is this absence due to nitrogen being changed in the soil to some other form than nitrate before being absorbed by the roots, or is nitrogen absorbed as nitrate and changed *within* the roots after absorption? What would be the effect on growth of the cane plant of nitrogen *within the plant in the form of nitrates*? What would be the effect on the percentage of germination, stand of cane, and final yield from cuttings from stools of cane into which had thus been injected various plant foods or stimulating chemicals? Could mosaic disease be transmitted by injecting into healthy plants liquids thus forced out from the stems and leaves of diseased plants?

VIII. SUMMARY

1. Experiments designed to approach the plant food requirements of sugar cane plants growing under field conditions through the analyses of their root pressure liquids are reported.
2. Two techniques of collecting these root pressure liquids under sterile conditions were developed.
3. Chemical analyses of root pressure liquids collected principally from H 109 cane in a number of different fields were made for pH value, total solids, loss upon ignition, nitrate, nitrite, albuminoid and total nitrogen, P_2O_5 , K_2O , SO_4 , CaO , SiO_2 , etc.
4. Because of the variance found to exist between the composition of these liquids and the composition of the soil (1 per cent citric acid), attempts are being made to interpret such discrepancies.
5. This method consists of comparing the amounts of various elements, or ratios of elements, contained in the collected root pressure liquids with those in culture solutions in which the plants are grown.
6. While ammonia and albuminoid nitrogen were present, both nitrate and nitrite nitrogen were notably absent from these liquids.
7. The quantity of liquid collected at night (6:00 p. m. to 6:00 a. m.) exceeded the amount collected during the day (6:00 a. m. to 6:00 p. m.).
8. These larger night quantities can be explained by the fact that the root pressure was higher at night than during the day.
9. Greater amounts of liquids were collected from stools of cane which had been fertilized than from stools which had not.
10. Columns of liquid as the result of root pressure filled and overflowed tubes more than 10 feet high.
11. The height of mercury columns (manometers) attached to stools of H 109, Lahaina, Yellow Caledonia, D 1135, and Uba cane were read every three hours throughout the day and night for a period of 21 days.

12. Columns of mercury as high as 140 cm. resulted, which height corresponds to water columns of more than 60 feet high.

13. When presented graphically the night readings show a rising curve while the day readings show a descending curve. The fact that higher pressures exist at night than during the day explains why greater quantities of liquid are obtainable during the night as compared with the amount obtainable during the day from the same stool of cane.

14. When irrigations were withheld from Uba, D 1135, Yellow Caledonia, and H 109 the falling off of the pressure curves over a 21-day period was greatest in the case of H 109, less in the case of Yellow Caledonia, still less in the case of D 1135, and least in the case of Uba. Listed in the order of the pressures maintained, these canes were in order of their drought resistances, namely, Uba, D 1135, Yellow Caledonia and H 109.

15. A burette filled with solution was attached to a single stalk of a stool of cane. Because of the underground connections with this stalk, the stalks of the stool left uncut, as the result of "leaf pull," drew into the body of the plant the solution in the burette.

16. This technique of "suction feeding" suggests a method of studying direct effects of various forms and amounts of liquids and gases, plant foods, enzymes, vitamins, disinfectants, stimulants, etc., when thus introduced "hypodermically" into stools of growing canes.

Sincere thanks are due first of all to the colleagues of my own department for their quick appreciation of the possibilities suggested by this work, to the head of the chemistry department and his associates for their ready cooperation in making the chemical analyses, to the sugar technology department for the sugar analyses, to many others whose enthusiasm was encouraging, and by no means least to my two faithful helpers who so willingly made the night readings and took care of the general details.

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A Report on the Local Use of Student's Method

BY O. H. LYMAN

The following report has been drawn covering the main points with additions, examples, and explanations, of a series of discussions held recently at the Experiment Station concerning Student's Method of plot yield analysis in comparison with other methods.

PURPOSE OF MATHEMATICAL STUDIES OF HARVEST DATA

In past years and in many cases today our experimental work with field tests has been given over to determining large responses due to the application of one plant food or another. Today we know without a doubt that nitrogen must be applied, that certain soils produce tremendous returns from phosphate additions, and still other soils yield us handsome profits from potash applications. With these facts established, we are left today with the task of determining the most profitable amount and time of applying these increases. The differences in yields become much smaller and increasingly more difficult to ascertain as we decrease the treatment variable. To obtain information as to the significance of these small differences we must turn to our mathematicians, who give us a number of methods, among others, the probable Error of the Mean Method, and Student's Method.

COMPARISON OF METHODS

In the "P. E. of the mean" method we have a measure of the reliability of the mean. This measure is represented by a figure immediately preceded by a plus and minus sign ($\pm$) following the average or mean under consideration, as 75 ± 2.5 , the 2.5 being the probable error of 75. This figure defines the range through which the average or mean may be expected to vary. Thus, if we harvest 10 plots, the mean yield of which is 60 tons, with a P. E. of this mean of 5 tons, (written 60.0 ± 5.0), we understand that if a large number of similar tests were run under conditions neither more nor less variable than those of this particular test, their means may be expected to fall between 55.0 ($60-5$) and 65.0 ($60+5$) tons in 50 per cent of the trials.

By referring to a table of odds derived from the normal probability curve, we can draw still further conclusions. The table of odds tells us that departures of twice the probable error may be expected to occur by chance once in 5.64 times. In the case under consideration, with its mean of 60 and its P. E. M. of 5, we understand that if this test were to be repeated many times under conditions neither more nor less variable than those of this test, the mean may be expected to fall between 50 ($60-2 \times \text{PE}$) and 70 ($60+2 \times \text{PE}$), 4.64 out of 5.64 times or about

82.3 times in a hundred. Similarly by again referring to the probability table, we can determine the chances of departures of three times the probable error, or of any other magnitude in which we may be interested.

To determine the P. E. of a difference between the means of two treatments A and B, we must first know the P. E. of the mean of A and the P. E. of the mean of B. The P. E. of the difference between these two means is equal to the square root of the P. E. of the mean of the A series squared, plus the P. E. of the mean of the B series squared.

$$PE_{M_A - M_B} = \sqrt{(P.E._{MA})^2 + (P.E._{MB})^2}$$

It should be noted, however, that the above formula is correct only when there is no correlation* between the plots of the A series and those of the B series. In a well laid-out field test, we may expect a fair correlation between the two series. The correlation may become marked when there is a fertility slope. In such an event, the coefficient of correlation must be calculated and used in arriving at the P. E. of the difference as indicated below:

$$PE_{M_A - M_B} = \sqrt{(P.E._{MA})^2 + (P.E._{MB})^2 - 2r_{AB} \times P.E._{MA} \times P.E._{MB}}$$

where r_{AB} represents the coefficient of correlation between the A and B series.

STUDENT'S METHOD

In Student's Method we have also a measure of reliability vested in a figure termed odds following the differences in the averages of the two paired treatments. Conventionally, odds approaching the arbitrary figure 30 to 1 or above are considered reliable. In other words, the chances of reproducing this gain or loss indicated are good when odds approaching 30 to 1 or more are recorded. It has been rightly stated that the figure representing odds with Student's Method is worth fully as much in the final analysis of the result secured as the difference between the treatments compared. In other words, the odds gives us a simple term on which to evaluate the reliability of the difference secured in the averages.

As has been stated, 30 to 1 odds is an arbitrary rating for reliability. Odds somewhat below this may give us reliability depending upon the magnitude of the differences and the number of comparisons. We should keep in mind the meaning underlying the odds figure, i.e., odds of 10 to 1 mean to us that in eleven trials the chances are that the difference noted between treatments would not occur more than once in eleven times where no variable treatment was applied as in a blank test where the variation is due entirely to soil. We feel that odds of 10 to 1 are too low for reliability so have raised our standard for security.

In Student's Method, we are able to pair off individual plots lying in similar

* By correlation is meant the tendency for the variables (in this case the varieties or treatments under test) to vary together rather than independently. Thus, all treatments or varieties tend to give yields higher than their averages in the best section of the experimental area, and lower than their averages in the poorest section.

conditions (plots adjoining each other or in close proximity). This eliminates to a considerable degree the effect of the fertility slope. No cognizance is taken of the fertility slope by the Probable Error of the Mean Method. By working with differences between adjoining pairs of plots it becomes unnecessary to introduce the corrections for correlation between the yields of the respective plots of the two treatments (Student's Method). Without this correction for correlation, the odds by the "P. E. of the mean" method may be quite wrong if the correlation is large.

Imagine for example a series as follows:

T. C. P. A.		T. C. P. A.	
1A.....	100	2B.....	90
3A.....	85	4B.....	80
5A.....	60	6B.....	50
7A.....	50	8B.....	45
9A.....	40	10B.....	35

The fertility slope in the above figures has been exaggerated to make the point clear. The P. E. of the means would be very large due to the great variation in yield between the different plots of the series. As a result, the odds that the difference is significant would be low unless the correction for correlation between the two series is introduced into the calculation (which, of course, should be done to get the correct answer). It is easier, however, to work with the differences themselves as in Student's Method, thus escaping the necessity of these laborious coefficient of correlation calculations.

DISCARDING OF PLOTS

If a plot is much higher or much lower than the other plots of the series it is natural to seek the cause. Sometimes the reason may be found rather readily. Errors in calculations of areas, mathematical calculations of weights, etc., poor stands of cane in the field, visible poor areas within a plot, proximity to a road or straight ditch, etc., may all bring about errors, which we may find by inspection. There are times, however, when we are unable to find the reason for the wide departure of a certain plot. Whether such plots should be retained or discarded is debatable. Perhaps our lack of knowledge as to the reason for a wide departure is not sufficient cause for including the widely departing plot in the series.

Several procedures have been suggested for dealing with aberrant plots.

BOND'S METHOD

Bond's method (*Hawaiian Planters' Record*, October, 1930) has calculated a table of omissions which when applied to Ewa data indicated that on the average, one plot from each test departs so widely as to warrant omission.

"TWENTY PER CENT OF MEAN" METHOD

Omission of departures greater than 20 per cent of the mean has also been suggested as a basis for discarding plots.

CHAUVENET'S CRITERION

Y. Kutsunai has adapted Chauvenet's criterion of omissions for use with Student's Method. This criterion is based on the standard deviation of the series. The larger the standard deviation, i.e., the greater the natural variability of the series of plots under consideration, the larger the departures allowable. This seems more rational than the "twenty per cent of the mean" procedure, which takes no cognizance of the inherent uniformity or variability of the series.

The method has another advantage. It sometimes happens that a plot of series A and an adjoining plot of series B are both so low or so high as to be thrown out if considered separately, even though the *difference* between them is of the same order of magnitude as the other differences in the series. By dealing with the differences between plots of series A and the corresponding plots of series B, rather than with the individual plot yields, it is found that these plots do not diverge abnormally and should not be excluded.

APPLICATION OF STUDENT'S METHOD

Several points in the application of Student's Method have caused differing opinions but after much discussion on the matter the following plan of attack appears best under the circumstances. No hard and fast rules may be laid down but when occasions permit the following procedure seems logical.

In a two-treatment test, A and B, it is deemed best to average the adjoining plots as follows:

1A	2B	3A	4B	5A	6B	7A	8B	9A	10B
1A averaged with 3A, result paired with 2B									
3A	"	"	5A,	"	"	"	"	4B	
5A	"	"	7A,	"	"	"	"	6B	
7A	"	"	9A,	"	"	"	"	8B	

Plots 9A and 10B cannot be compared as the weight given 9A will cause an unequal value for this plot in the average figure. In a three-treatment test, A-B-C, no averaging should be made as all comparisons are aligned regularly and adjoining, thus:

1A	2B	3C	4A	5B	6C	7A	8B	9C	10A
1A compared with 2B									
4A	"		"	5B					
7A	"		"	8B					

2B compared with 3C			
5B	"	"	6C
8B	"	"	9C
4A	"	"	3C
7A	"	"	6C
10A	"	"	9C

In a four-treatment test, A-B-C-D, comparisons of A and B, B and C, C and D, and A and D may be made as in the three-treatment test as all of these comparisons may be found to be directly adjoining: The A and C comparison (non-adjoining plots), a system simulating that of the two-treatment test, is advantageous:

1A	2B	3C	4D	5A	6B	7C	8D	9A	10B	11C	12D
1A averaged with 5A, result paired with 3C											
5A	"	"	9A,	"	"	"	"	7C			

9A cannot be compared with 11C as the weight in the average of 9A will be excessive when averaged with the other A plots.

It will be found of great advantage to have in mind at the time of installation of a new experiment the method of analysis of the harvest data. Where Student's Method is to be used on the yields secured it is advantageous to include extra plots comparing A and C, previously referred to, as directly adjoining. This will eliminate any necessity of averaging non-adjoining plots.

In a variety test where checks are located on either side of each variety plot we may make the following comparisons:

1A	2B	3A	4C	5A	6B	7A	8C	9A	10B	11A	12C
A=Check											
B=Variety No. 1											
C=	"	"	2								

1A averaged with 3A, result paired with 2B			
5A	"	"	7A, " " " 6B
9A	"	"	11A, " " " 10B
3A	"	"	5A, " " " 4C
7A	"	"	9A, " " " 8C
11A			" " 12C

11A may be compared with 12C directly as the balance of the A plots will not be unduly upset when 11A is given full value.

It was thought best to base our odds on cane instead of sugar where the reliability of the juice sampling may be questioned and where no significant difference or trend is to be noted in the juice figures. Basing odds on sugar in such cases, it is felt, introduces an additional source of error into the calculations.

Special attention should be given the juice figures from amounts of nitrogen, time of nitrogen, and like experiments, as these figures are very often significantly

changed by the treatment, and sugar should be the controlling factor. It was agreed to run odds for variety tests on sugar whenever possible.

APPLICATION OF STUDENT'S METHOD TO ACTUAL YIELD DATA

Let us make a few comparisons of averages secured by Student's pairings and general averages as regularly used. The following actual examples will serve as illustrations:

EXPERIMENT 34 AN. H. C. & S. CO. GENERAL AVERAGES

N. Lbs.	T.C./Ac.	Q.R.	T.S./Ac.	Difference
R 204	47.1	7.45	6.32	.....
S 279	52.6	7.52	7.00	+0.68
T 354	56.0	7.53	7.44	+1.12

There appears to be a good consistent gain up to and including the maximum treatment.

STUDENT'S PAIRED PLOT AVERAGES

					Odds on Cane
R 204	45.6	7.45	6.12	.....	454 to 1
S 279	52.9	7.52	7.03	+0.91	
R 204	44.5	7.45	5.97	.....	212 to 1
T 354	51.8	7.53	6.88	+0.91	
S 279	53.0	7.52	7.05	.....	2 to 1
T 354	53.8	7.53	7.14	+0.09	

Here we get an entirely different slant on the proper amount of nitrogen to apply. We find no additional gain for the 354-pound treatment over the 279-pound treatment as was found in the general averages. We may have assurance that the gain represented will be somewhere near the gain which may be expected again under similar conditions as the odds are large, denoting great probability that the figure is true. We also find that the gain of the 354-pound treatment over the 279-pound treatment is due entirely to chance as the odds show us that the plots do not produce consistent gains, favoring the higher treatment as the general averages lead us to expect.

EXPERIMENT 50 AP PIONEER MILL CO. GENERAL AVERAGES

	P ₂ O ₅ Lbs.	T.C./Ac.	Q.R.	T.S./Ac.	Difference
R	100	84.3	7.0	12.04	.....
S	200	85.9	7.0	12.27	+0.23
T	300	87.8	7.0	12.55	+0.51
U	400	81.6	6.9	11.82	-0.22

There appears to be a consistent gain for applications up to 300 pounds.

STUDENT'S AVERAGES							
		P ₂ O ₅ Lbs.	T.C./Ac.	Q.R.	T.S./Ac.	Difference	Odds
R	6	100	84.6	7.0	12.08	.....	.....
S	6	200	84.2	7.0	12.03	-0.04	2¾ to 1
S	6	200	87.0	7.0	12.42	.....	.....
T	6	300	87.0	7.0	12.43	+0.01	2 to 1
T	6	300	87.0	7.0	12.43	.....	.....
U	6	400	84.7	6.9	12.27	-0.16	1¾ to 1
R	9	100	84.1	7.0	12.02	.....	.....
T	9	300	86.9	7.0	12.42	+0.40	3 to 1

These results show us at a glance that we have no guarantee of response from phosphate applications. Needless to say this does not support the general averages.

Additional instances of this same character where general averages give erroneous information may be found if reference is made to Experiment 22AP, H. C. and S. Co and Experiment 71AK, Pioneer Mill Co. 1931 crop.

An example is presented to show another phase of the question:

EXPERIMENT 17 PK. PIONEER MILL CO. 1931 CROP

GENERAL AVERAGES				
	T.C./Ac.	Q.R.	T.S./Ac.	Gain
N	44.9	6.44	6.98	.....
NP	63.3	6.92	9.14	+2.16
NK	48.8	6.64	7.34	+0.36
NPK	66.8	6.83	9.77	+2.79

There appears to be a good gain from phosphate and a fair additional gain from potash.

	T.C./Ac.	Q.R.	T.S./Ac.	Gain	Odds in Sugar
N	44.9	6.44	6.98	.....	.....
NP	65.3	6.92	9.44	+2.42	1999 to 1
N	44.9	6.44	6.97	.....	.....
NK	47.7	6.64	7.19	+0.21	12 to 1
N	45.5	6.44	7.07	.....	.....
NPK	66.0	6.83	9.66	+2.56	102 to 1
NP	64.4	6.92	9.31	+1.49	22 to 1
NK	51.7	6.64	7.78	.....	.....
NP	66.3	6.92	9.58	.....	.....
NPK	65.5	6.83	9.59	+0.01	less than 1 to 1

Excellent gains are found for phosphoric acid supported by high odds. The gain for the potash addition to nitrogen is quite small, unsupported by good odds.

When the phosphate addition is compared with the phosphate and potash addition no gain is to be noted from potash. This is rather contrary to the general figures, which show a 0.63 T.S./Ac. gain for the potash comparing the NP and NPK averages.

In still other cases we may have a gain of one treatment over another in nearly every comparison, but if these gains are extremely variable from one comparison to another the odds will be low, yet a good sugar gain will be reported. We must naturally concede a gain to the treatment even in spite of the low odds. When graphed the results will show this plainly. Again, on the other extreme, a very small uneconomic but consistent gain may be found in the series of comparisons for one treatment over another such that the odds work out to be over 9999 to 1. This does not mean that we should increase the fertilization. The magnitude of the differences between comparisons must be considered as well.

As another case for illustration, let us take Experiment 49 AN at Pioneer Mill Company.

GENERAL AVERAGES

	N. Lbs.	T.C./Ac.	Q.R.	T.S./Ac.	Difference
D	150	70.5	6.8	10.37	.....
E	200	77.1	6.8	11.34	+0.97
F	250	81.9	6.9	11.87	+1.50
G	300	86.3	6.9	12.51	+2.14

STUDENT'S METHOD GIVES

	N. Lbs.	T.C./Ac.	Q.R.	T.S./Ac.	Difference	Odds
D	150	71.6	6.8	10.53	.....	....
E	200	78.1	6.8	11.49	+0.96	174
D	150	71.6	6.8	10.33	.....	....
F	250	83.9	6.9	12.16	+1.83	1249
D	150	69.9	6.8	10.18	.....	....
G	300	86.5	6.9	12.53	+2.35	1666
E	200	75.9	6.8	11.16	.....	....
F	250	81.1	6.9	11.76	+0.60	7¼
F	250	81.5	6.9	11.81	.....	....
G	300	86.3	6.9	12.51	+0.70	6¼

Differences appear quite similar to the general averages in the first three comparisons. In the last two the differences become more difficult to secure and the differences will be found to vary more and more. The low odds here are due entirely to plot variations. Such cases must be considered from all evidence at hand, averages, odds, graphs and common sense, as no guides can be made up to suit all cases. A degree of doubt is shown in this experiment, however, over the gains made by the two higher applications which are not indicated by the general averages.

These illustrations go to show that fallacies may be represented in general averages which are not apparent unless a careful analysis is made. It is not meant to

convey the impression that general averages in all cases differ radically from Student's averages, the trend in many cases is identical, but that differences often occur and we must have means for determining these errors.

GRAPHIC ILLUSTRATION OF PLOT YIELDS

It is quite possible to bring out graphically an accurate picture of the plot yields to show at a glance the difference in treatments qualitatively. It is difficult without representing the averages to judge the exact quantitative response, however. Averages are often transferred from the original sheets to find their way to summarization of the crop, various and sundry reports, and are often noted on maps of the repetition of the test. It is quite impossible to carry along the graph to depict the quality or reliability of the response in these cases. A single figure denoting the measure of reliability as odds is quite superior in this respect.

Where no measure of the reliability of the average differences is attached to the write-up and the averages have been transferred and retransferred the reliability of the results is invariably forgotten. A large gain or loss may be represented and this is taken at its face value, producing as a result an extremely erroneous impression or even a costly mistake.

It is not intended to create the impression that graphs should be omitted from the original experimental write-up, but it is felt that their value is limited and cannot fully fill the place of the reliability figure—odds.

Manganese as an Essential Element in the Growth of Sugar Cane

BY L. E. DAVIS

Prior to the beginning of the present century ten elements were generally considered essential for the growth of plants. These elements are: carbon, hydrogen, oxygen, nitrogen, phosphorus, sulphur, potassium, calcium, magnesium and iron.

As a result of recent investigations there is now considerable evidence to indicate that this list should be extended. Although the subject is still quite controversial, many conservative students of plant nutrition seem inclined to favor the view that two or more other elements besides those listed above are probably essential to at least some plant species (1).

Manganese, copper, boron, zinc, and other elements are considered by many investigators to be capable of stimulating plant growth when available in minute quantities (1, 2, 3). Many of these elements are undoubtedly toxic to most plants when present in concentrations exceeding a few parts per million of the nutrient solution (4, 5).

A substance may conceivably stimulate certain functions of plants or animals under proper conditions, and still not be absolutely indispensable. This is true of a large number of organic and inorganic compounds as can be seen from a casual glance through the *United States Dispensatory*.

Persistent effort has been made to answer the question "Is manganese (and/or copper, etc.) indispensable to plant growth?" (6, 7, 8.) Obviously to answer this question finally, four conditions are necessary:

(a) Plants must be grown both with traces of the element in question present in the root zone and in an environment free from the element.

(b) A sufficient number of widely different species must be studied to establish a reasonable presumption that the individual conclusions have general application. Obviously all species and their varieties cannot be examined. In this sense we cannot rigorously prove that even potassium or calcium are universally essential.

(c) The experiments should be conducted under varied conditions to exclude the possibility that the element, while essential under one condition, may not be indispensable under all conditions. Again, our assurance is limited by our inability to carry out an indefinite number of experiments.

(d) The possibility that other elements can be successfully substituted for the one being studied must be eliminated.

Manganese probably has been studied more carefully and by a larger group of workers than most of the elements formerly considered non-essential. The careful work of Oswald Schreiner, W. E. Brenchly, J. S. McHargue, G. Bertrand, F. T. McLean, G. Samuel, C. S. Piper, O. C. Bryan and others has demonstrated that species as diverse as tomatoes and sugar cane require traces of manganese (8, 9, 10, 11, 12, 13, 14, 15).

When plants are grown in culture media very carefully freed from manganese but containing sufficient quantities of elements known to be essential and with traces of others such as boron and zinc, a chlorosis of the leaves appears in a few weeks, even with quite large amounts of iron present. This chlorosis is often characterized by an alternation of yellow-white tissue with green tissue. In the tomato and tobacco the etiolated areas appear as spots; in sugar cane and maize they form stripes (8, 9, 10). The leaves may then begin to wither and become twisted. Splitting along the chlorotic streaks or stripes then occurs in severe cases followed by reddening of the tissues and death of the leaves. The plant becomes stunted and may eventually die after a short period, although new leaves, free from chlorosis may temporarily appear, only to wither and die.

In sugar cane these symptoms are characteristic of a disease commonly known in Hawaii as Pahala blight (10). In the field this disease has been successfully controlled by McGeorge, who made large applications of sulphur to the soil. W. W. G. Moir and Raymond Conant recently have removed the symptoms of this disease with applications of manganese compounds either to the leaves or to the soil. Similar results were obtained by Atherton Lee, J. C. Thompson and Royden Bryan (10).

Quite frequently the disease appears very early in young cane but disappears later in the season. Only in very severe cases does it result in a complete stunting of the cane, followed by death.

Following his local studies of this disease, Lee collaborated with J. S. McHargue, of Kentucky Agricultural Experiment Station, who is a pioneer in work with manganese. McHargue had observed chlorotic symptoms in oats and wheat which resembled the chlorosis found in Pahala blight of sugar cane, when those cereal plants were grown without manganese.

McHargue grew cuttings of Yellow Caledonia in sand cultures, some of which contained small amounts of manganese and others of which were free from that element.

The cuttings grown with manganese-free solutions showed very definite chlorotic stripes while those with manganese present were normal. This work is described by Lee and McHargue in the reference cited herewith (10).

During the spring of 1928, G. R. Stewart, then chemist of this Experiment Station, inaugurated a series of water culture studies with the object of determining the requirement of sugar cane for various elements such as manganese, silicon, fluorine, iodine, bromine, zinc, boron, copper and titanium.

Some very carefully repurified chemical nutrients were prepared by Fred Hansson. C. P. chemicals were repeatedly crystallized until they were free from the elements to be used in the experiments. A very large proportion of the success realized in the experiment discussed below must be ascribed to the careful purification of the chemicals used. All recent investigators have emphasized the necessity of using chemicals very carefully purified to exclude manganese. The presence of traces of this element in the supposedly manganese-free cultures may cause negative results although occasionally very small amounts may be insufficient to favor normal growth (8).

The cultural studies described in the following paragraphs were assigned to the author, who carried out the experiments under the supervision of Mr. Stewart.

Seed pieces of H 109 cane, a variety not extremely susceptible to Pahala blight, were obtained from Waipio substation through the courtesy of J. A. Verret. These seed pieces were planted in silica sand which had been digested with hydrochloric acid and repeatedly washed with distilled water. Following a technique devised by McGeorge, the young shoots were excised with some care, in order to eliminate as much seed piece tissue as possible. Thus the amount of residual manganese which might be derived from the parent cane was brought to a minimum.

The cane shoots were immediately transferred to pyrex glass flasks capped with small wood covers coated with a clear lacquer free from soluble substances.

The basic nutrient solution was prepared from doubly distilled water condensed in black tin and collected in pyrex glass receivers. The composition of the culture solution was very nearly that used by Sommer in California in her work on boron and zinc; the potassium nitrate was reduced somewhat (6).

	Parts per Million
Potassium nitrate, KNO_3	575
Monopotassium phosphate, KH_2PO_4	150
Magnesium sulphate, $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$	500
Sodium chloride, NaCl	12 /
Aluminum sulphate, $\text{Al}_2(\text{SO}_4)_3 \cdot 18 \text{H}_2\text{O}$	6.2
Iron tartrate, Mn free	5.0
Calcium sulphate, CaSO_4 , 300 cc. saturated solution per liter of nutrient	....
The reaction of this solution was about 5.8 pH.	

The following elements were also added to certain of the cultures:

	Parts per Million
Iodine (as potassium iodide) $\text{I}=\text{.....}$	0.5
Fluorine (as sodium fluoride) $\text{F}=\text{.....}$	0.5
Silicon as small amounts of dialyzed silica.	

These elements were distributed in such a way among both the manganese-free cultures and the controls that various combinations were possible. There were three sets of four plants each receiving no manganese or twelve in all, and five sets of four plants each receiving manganese at a concentration of 0.5 part per million. Two of the latter were accidentally injured while changing the nutrient solutions, leaving eighteen control plants. The culture solution was completely changed about every four days and was also brought up to a uniform volume daily.

During the first two weeks all plants became slightly chlorotic. The entire leaf surface of a number of leaves was a rather pale green, but there was no striping. The controls, containing manganese, were slightly more chlorotic than the manganese-free cultures. Excess iron tartrate was immediately added. Within a day or two all the plants assumed a normal, lustrous green color. The iron ration was then maintained at 20 parts per million of iron tartrate (about 5

parts per million of iron), which was sufficient to maintain the controls in a healthy green condition throughout the experiment.

In less than four weeks a number of the plants which were not receiving manganese showed a tendency toward a chlorotic striping of the leaves. In seven weeks this chlorosis had become severe on all the leaves of all the plants that were grown without manganese. At no time subsequent to the addition of excess iron mentioned above was there any appearance of the uniform etiolation which is usually considered characteristic of iron-deficiency chlorosis.

At the end of three months, an attempt was made to restore six of the manganese-free plants by supplying them regularly with the same solution as the controls, i.e., a solution containing 0.5 part per million of manganese.

In the manganese-free cultures the affected leaves began to wither and became severely twisted and intertwined. This condition was followed by splitting along the chlorotic stripes and by the appearance of reddish spots which later became reddish-brown streaks. All of these earlier leaves withered and finally died.

In five months when growth had apparently ceased for some time, new green leaves began to appear. These leaves did not become chlorotic but rapidly (i.e., within a week or two) withered. In all cases the entire plant was now in a very poor condition and three of the six began to die; one was apparently already dead at the end of six months. At this time the whole experiment was harvested.

Five of the chlorotic plants to which manganese had been added began to put out new green leaves within a month of the first addition. These leaves grew normally but rather slowly. The sixth plant did not appear to have sufficient vitality to recover although some new leaves appeared.

All of the control plants were apparently healthy, quite green, and still growing slowly at the time of harvest, although they were root-bound in the rather small containers.

Roots, stems, leaves, tops, and trash of all plants were collected, carefully dried, and weighed. A tabulation of individual dry weights of the combined tissues of each plant is to be found in the table below. Roots, tops with leaves, and stalks were separately weighed. Each of the separate parts of every manganese-free plant was proportionately smaller in weight than the corresponding tissues of the control plots; therefore, to avoid presentation of superfluous data, only the total plant weights are given here.

DRY WEIGHTS OF EACH PLANT IN GRAMS

Manganese-free plants		Controls	
No. 3	14.1	No. 5	39.2
4	17.4	6	38.9
11	19.1	7	49.9
12	16.8	8	39.2
23	8.8	13	33.2
24	9.3	14	27.0
Average		15	44.3
Manganese added after 3 months		16	24.5
		17	60.8
		19	20.4
		20	26.8
No. 1	38.3	25	41.9
2	27.2	27	43.4
9	31.1	28	36.0
10	14.1	29	18.5
21*	10.8	30	35.6
22	21.0		
Average		31	37.5
		32	41.5
		Average	
		36.6	

* This plant did not recover.

The control plants weighed on the average 22.3 grams more than those receiving no manganese, or showed 2.5 times as much growth, and weighed 12.5 grams more than those receiving manganese during the last three months, or showed 1.5 times as much growth. These results were found to be highly significant by a mathematical analysis. The method was obtained from Fisher's *Statistical Methods for Research Workers*.

The plants receiving manganese for three months weighed 9.5 grams more than those receiving no manganese or 1.6 times the growth. This difference was mathematically of doubtful significance. The odds were low (about 20 to 1) because one of the plants failed to recover and consequently the distribution was less uniform than if all six had shown approximately equal improvement.

The experiment was followed by others in which an iron salt containing small amounts of manganese as an impurity was used in all cases. In no instance was there any appearance of chlorosis of any type. The objective of four of these experiments was to determine whether any of the following elements was essential: boron, copper, iodine, fluorine, bromine and zinc. Evidence was obtained indicating that copper and boron were stimulating but it was not proved that they were essential. Indeed the fact that the controls grew normally in the first experiment, although no copper or boron were added, would suggest that copper and boron are possibly not essential. However, no special effort was made to be absolutely certain that copper or boron were absent as impurities. Recent work by Sommer, who very carefully eliminated all traces of copper and boron from

her solutions, indicates that copper and boron are essential, even in the presence of manganese, for certain plants (7).

In a sixth experiment increasing amounts of manganese were used in addition to that present as an impurity (i.e., about 0.2 part per million). The amounts added were: 1.5, 3, 4.5 and 6 parts per million. Five parts per million of iron were used in all cases. All the plants grew fairly well, although the variety used was Lahaina. The best growth was observed with 4.5 and 6 parts per million of manganese. The differences were 11.9 grams and 11.6 grams more weight respectively than those receiving manganese as an impurity only. The plants were paired by choosing for excision and transplanting five cuttings (one for each experiment) at intervals of about 4 days. The odds by Student's method were about 200 to 1.

These experiments confirm the results achieved by Lee and McHargue (10). A disorder having the symptoms of Pahala blight occurs in sugar cane grown in cultures free from manganese. In the field Pahala blight can be remedied by applications of manganese compounds. It is reasonable to conclude that the disorder experimentally induced by McHargue and by the author is identical with Pahala blight, and that Pahala blight is a physiological disease due to deficiency of manganese. The results obtained by the author appear to go further in that they show that sugar cane cannot survive in water cultures without manganese, and that given a sufficient supply of other nutrients, a moderately large concentration of manganese is not toxic to sugar cane but is actually stimulating.

To return to the four conditions discussed earlier in this paper:

1. It is apparent that a manganese-deficiency disease of sugar cane can be achieved with certainty only where the solutions are very carefully freed from manganese. In this connection it must be remembered that the plants used all had opportunity to derive a small amount of manganese from the parent cane. However, under certain conditions the amounts of manganese available from the soil solution in the field appear to be insufficient, and applications of manganese can be recommended.

2. The author has contributed results applicable only to *Saccharum officinarum*, var. H 109. Nevertheless the results of McHargue with Yellow Caledonia (10) and with oats and wheat (15) and results achieved by others with oats, tomatoes, corn and tobacco (4, 8, 9, 11, 12, 13, 14) indicate that manganese may be essential to many varieties of plants.

3. Experiments connecting chlorosis with manganese deficiency have been carried out in water cultures, sand cultures, soil pots and in the field in a variety of soils and climatic conditions.

4. The question still remains: Can other elements be substituted for manganese? This is still an open question. No experimental results with sugar cane are known to the author which definitely exclude the possibility that other elements may produce the same effects as manganese. O. C. Bryan found that manganese and copper both appeared to control a chlorosis of cowpeas, beans, and sorghum grown in the raw peat soils of the Florida Everglades, but that the best results were achieved with both copper and manganese present (18). G. Samuel and C. S. Piper have recently demonstrated, however, that neither boron,

aluminum, zinc, copper, cobalt, nickel, barium, silicon, or iodine could replace manganese in tomatoes and in various grasses grown in carefully purified culture media (8).

Several theories have been advanced to explain the action of manganese. Apparently none of these rest upon adequate experimental evidence (11, 13, 20). It is assumed by several writers that manganese acts as a catalyst, that in some way it activates processes in the plant which control the formation of chlorophyll. It is possible that manganese acts as an oxidizing-activator for iron. Sideris has recently suggested that there is most probably some such relationship between titanium and iron. It must be remembered that such terms as catalyst, activator, etc., are inevitably vague since they cover a lack of precise knowledge.

The conclusion tentatively reached is that manganese by some mechanism at present unknown, aids in the normal formation of green tissue, and that in the complete absence of manganese sugar cane cannot be grown normally and in fact fails to survive after a period of a few months.

The following cited literature represents but a small proportion of the growing literature available upon this subject, and upon the stimulating effect and indispensability of other elements.

SUMMARY

In the past ten elements have been considered essential to plant growth. Probably other elements, in particular manganese, should be considered indispensable. A chlorotic disorder similar in its symptoms to Pahala blight of sugar cane has been found in several species of plants to be associated with a deficiency of manganese. More specifically, Lee and McHargue found that the symptoms could be induced in sugar cane grown in water cultures from which manganese was carefully excluded. The author has succeeded in confirming this result and in demonstrating further that the condition proceeds from bad to worse and finally ends in death of the plant. He has also shown that manganese is stimulating to sugar cane in relatively large concentrations, provided other nutrients are present in sufficient amounts. It is concluded tentatively that manganese is essential to sugar cane.

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A Rapid Method for the Determination of Potash

BY PAUL L. GOW

INTRODUCTION

During the last two years we have come to feel very keenly the need for rapid and sensitive analytical methods which are capable of as high, or in some cases higher, degrees of accuracy as are the standard methods heretofore applied to soils, soil extracts, percolates and irrigation water.

A number of factors more or less peculiar to the work in which this laboratory has been engaged have contributed to this demand. Some of these factors are: (a) the necessity of rapidly handling a great many routine analyses for the purpose of regulating fertilization; (b) the necessity of making large numbers of analyses in connection with special researches which require the determination of only one or two substances instead of the usual more complete analyses; (c) the desirability of making surveys of soils, irrigation waters, etc., with respect to only one or two of their constituents; (d) the necessity for increased accuracy for certain special problems; and (e) the chemical peculiarities of the types of samples with which we have to deal.

In particular, soils and soil extracts offer materials for analysis which are chemically very complex and which therefore entail many vexing analytical problems. In applying the ordinary analytical methods to such materials the time and effort involved in analysis are increased while the accuracy and reliability of the methods are decreased. Many Hawaiian soils, moreover, possess comparatively large amounts of extractable titanium and manganese and appreciable quantities of vanadium and other minerals which tend to interfere with analytical procedure and intensify the difficulties and inaccuracies inherent in soil analyses.

Especially was it desirable to secure a new method for the determination of potash in materials where the amounts of potash present are usually very small. The Lindo-Gladding gravimetric method heretofore used is much too slow and tedious to allow of its use in many investigations involving analysis of a large quantity of samples, especially if the determination of only potash or potash and phosphate is desired. Moreover, it seems impossible to secure by means of this method, when applied to the materials with which we have to deal, the degree of accuracy which we desire for much of our work without employing refinements of procedure which would render the method so slow and unwieldy as to prohibit its use.

A number of methods for potash determination were investigated and found unsatisfactory, including the Hill (1) colorimetric method as outlined by Yoe (2) in his book on photochemical analysis. However, after rather extensive experimentation certain modifications of the method were developed which made it admirably applicable to much of our work. By this modified Hill method we found that samples can be analyzed in a quarter or less of the time required by

the Lindo-Gladding method, and that less of the analyst's time and attention and considerably smaller quantities of reagents and apparatus are required. With soil extracts and waters our modification of this method enables the analyst to obtain a higher degree of accuracy than does the standard method. The chief limitation on the new method is that it cannot give as high a degree of accuracy as can the gravimetric method with materials containing relatively large quantities of potash such as cane stalks and leaves, crusher juices and fertilizers. The accuracy of the method is strictly limited by the degree of accuracy with which intensities of color may be compared. This is such as to allow determinations to be made to three significant figures, while with materials containing more than 1 per cent K_2O it is usually desirable to make determinations to four significant figures. However, it is precisely with this class of analyses that the gravimetric method is not open to the serious objections which we found to apply in the case of soil extracts, soil percolates and irrigation waters.

DESCRIPTION AND THEORY OF THE COLORIMETRIC METHOD

This method consists essentially of precipitating potassium chloroplatinate (K_2PtCl_6) by means of its insolubility in alcohol, dissolving the precipitate in water and developing a color by the addition of stannous chloride ($SnCl_2$). The intensity of the yellow color thus produced is directly proportional to the amount of platinum present in the precipitate and hence to the amount of potash present.

The gravimetric method requires the removal of organic matter, silica, iron and alumina, calcium and ammonium salts before the precipitation of the potassium chloroplatinate; but the colorimetric method requires the removal only of organic matter, ammonium salts and silica, if it is present in much quantity. Moreover, the gravimetric method depends upon the weight of the precipitated salt while the colorimetric method depends only on the amount of platinum present in the precipitate. Impurities which would give rise to errors in the gravimetric method have no effect on the colorimetric method, the only impurities affecting the latter method being platinum or some colored substance not reducible by stannous chloride, both of which are very easy to guard against.

Nowhere in the literature dealing with this method is there any mention of the reaction to which this color is due. However, Friend (3) states that chloroplatinic acid (H_2PtCl_6) is reduced to chloroplatinous acid (H_2PtCl_4) by sulphur dioxide in aqueous solutions, changing the color of the solution from yellow to deep red. We have found that the color produced by stannous chloride in strong solutions of platinic chloride is a deep red, which becomes orange and then yellow on dilution. Hence, the reaction to which the color is due is probably:



ANALYTICAL PROCEDURE

A sample should be chosen, where possible, of such size as to contain between 1.0 and 10.0 mg. of K_2O . In the case of a soil extract or water in which K_2O alone is to be determined, the sample, usually 100 ml., should be evaporated in a

porcelain dish to dryness and then carefully ignited. The muffle should be at low red heat and the sample left in just long enough to destroy the organic matter and drive off any ammonium salts which may be present. The residue is then taken up in 20 to 30 c.c. of dilute hydrochloric acid and heated for a few minutes on the steam bath. If silica appears in appreciable quantities, or if much carbon has been left from the ignition the sample should be filtered into another porcelain dish.

If the sample is an extract which is to be analyzed for other substances besides potash, the ordinary procedure for such analysis may be followed until silica has been separated. The filtrate and washings from the filtration of silica should be caught in a 100 ml. volumetric flask, the volume made up to the mark, and 25 ml. taken for potash determination and placed in a porcelain evaporating dish.

Platinum chloride solution is then added, 1 to 3 c.c. of 2 per cent solution usually being sufficient.

The sample is evaporated to dryness on the steam bath. (It is best to allow the residue to become completely dry. It will not hurt even if it bakes on the steam bath for some time.) The dish is then cooled and the residue taken up in 20 to 30 c.c. of 92 to 95 per cent ethyl alcohol. The residue must be thoroughly broken up with a policeman to enable solution of all soluble material. The alcohol is then decanted into a Gooch crucible to which suction is being applied. The residue should now be thoroughly ground up with the policeman and washed into the crucible by means of a stream of alcohol. Four washings under suction with small portions of alcohol will be sufficient to remove all excess platinum chloride. The crucible is then dried for a few minutes at about 100° C. to remove the alcohol.

The crucible is now placed upright in a funnel and the K_2PtCl_6 is washed through with hot water acidified with a HCl. The washings are caught in a 250 ml. volumetric flask (a 100 ml. flask if the quantity of K_2PtCl_6 is very small). After cooling the volume is made up to the mark and an aliquot is pipetted off into a 100 ml. volumetric flask. Fifteen to 20 c.c. of concentrated hydrochloric acid and 5 c.c. of stannous chloride solution are then added. The color develops immediately. The volume of the solution is then made up to 100 ml. and the color is compared with that of a standard solution by means of a colorimeter.

The choice of the proper aliquot for the development of the color is the most difficult part of the analysis. The amount of precipitated K_2PtCl_6 may serve as a guide to an experienced worker, but the appearance of this precipitate is often misleading as to the quantity of K_2PtCl_6 contained therein. For accurate work the intensity of the color of the solution to be compared should not be more than twice nor less than half that of the color of the standard. For samples containing more than 4 mg. of K_2O the solution of K_2PtCl_6 when made up to 250 ml. volume will have a yellow color due to the K_2PtCl_6 . This color may be used to indicate the necessary dilution by roughly comparing with a set of permanent preliminary standards made up by dissolving various amounts of K_2PtCl_6 in water acidified with HCl and kept in 250 ml. volumetric flasks. For concentration of K_2O less than 4 mg. in 250 ml. it may be necessary to make two attempts at securing the proper dilution before the color developed is within the range of the standard. It is well to err on the side of too little dilution when the necessary dilution is not known. If the solution proves to be too concentrated after the development of the

color it may be diluted again by merely adding water and the proper quantities of stannous chloride and hydrochloric acid. We have found that this procedure does not introduce any error. It is often convenient to prepare two standards, one containing 0.004 mg. K_2O per ml. and the other containing 0.002 mg. per ml.

The standard solution is made by weighing out 0.3166 g. KCl or 0.3700 g. K_2SO_4 , dissolving in water and hydrochloric acid and precipitating as usual with platinum chloride. The precipitated K_2PtCl_6 is dissolved in hot water, 40 to 50 c.c. of concentrated hydrochloric acid is added and the solution is made up to 500 ml. One hundred ml. of this solution is used to make one liter of standard which contains 0.04 mg. K_2O per ml. When this standard is to be used, 10 ml. is taken together with 20 c.c. of concentrated hydrochloric acid and 5 c.c. of stannous chloride solution and the volume is made up to 100 ml. This solution contains 0.004 mg. of K_2O per ml. The color standard should not be made up until it is needed. If properly acidified to prevent hydrolysis, the standard K_2PtCl_6 solution will keep indefinitely.

The stannous chloride solution is made by dissolving in concentrated hydrochloric acid as much metallic tin as it will dissolve. The solution is kept with a few pieces of tin in contact with it and should be protected from the air as much as possible. It is best to keep it in an aspirator bottle with a layer of mineral oil over the top of the solution.

EXPERIMENTAL INVESTIGATION

The following tables give the results of investigations undertaken to determine the accuracy of the colorimetric method:

TABLE I

A set of 10 samples were analyzed by the usual gravimetric method. After weighing, the K_2PtCl_6 was dissolved from the crucibles and determined colorimetrically to determine if the color was, in fact, strictly proportional to the amount of K_2PtCl_6 present.

Per Cent K_2O Colorimetric	Per Cent K_2O Gravimetric
0.021	0.022
.025	.024
.033	.039
.020	.021
.030	.035
.041	.041
.021	.021
.032	.033
.036	.036
.024	.033

TABLE II

Samples were analyzed both colorimetrically and gravimetrically. In the case of these samples the colorimetric determinations were entirely separate from the gravimetric determinations.

Colorimetric Method	Gravimetric Method	
0.021	0.022	} Citric acid extracts Numbers represent Per Cent K_2O
0.019	0.019	
0.020	0.023	
32	32	} Irrigation waters Numbers represent p. p. m. K_2O
31	36	
33	36	
32	36	
32	36	

TABLE III

Duplicate samples were analyzed colorimetrically to determine if the method is capable of checking itself over a wide range of concentrations.

Citric Acid Extracts Per Cent K_2O	Water Extracts p. p. m. K_2O	Water Solutions of KCl p. p. m. K_2O
{ 0.019	{ 10.2	{ 204
{ 0.018	{ 10.0	{ 204
{ 0.021		
{ 0.018	{ 13.7	{ 194
	{ 14.0	{ 192
{ 0.022		
{ 0.022	{ 17.8	{ 52.8
{ 0.023	{ 18.2	{ 52.4
{ 0.020	{ 32.0	{ 40.4
{ 0.021	{ 32.0	{ 41.2
{ 0.027	{ 83.2	{ 212
{ 0.027	{ 81.2	{ 206
{ 0.028	{ 156	{ 206
{ 0.028	{ 156	{ 208
	{ 4.4	
	{ 4.4	
	{ 25.2	
	{ 24.4	
	{ 53.2	
	{ 52.8	
	{ 120	
	{ 118	
	{ 190	
	{ 192	

These results may be taken as indication of the accuracy obtainable by this method. When carefully applied results may be secured which are reasonably correct to three significant figures. The accuracy is limited by the accuracy with which colors may be compared in the colorimeter. For such small quantities this is as great accuracy as can be expected from any method.

TABLE IV

A set of colorimetric determinations was made on 100 ml. portions of the same citric acid extract to which varying quantities of K_2O had been added.

Mg. K_2O Added	Theoretical Per Cent K_2O	Per Cent K_2O Found
0	....	0.022
0	....	.022
0	....	.023
2	0.042	.041
4	.062	.064
6	.082	.084
8	.102	.102
10	.122	.121
12	.142	.140
14	.162	.162
16	.182	.172
18	.202	.202

TABLE V

An investigation was undertaken to determine the optimum amounts of stannous chloride solution and hydrochloric acid to be used in developing the color, and to determine whether the intensity of the color was at all dependent upon the amounts of the reagents used. In this table the ratios given are the ratios of the intensity of the solution under investigation to that of a standard solution containing 0.2 mg. K_2O as K_2PtCl_6 ; 5 c.c. of stannous chloride solution and 25 c.c. of concentrated hydrochloric acid in 100 ml. of solution. The solutions whose colors were to be compared all contained 0.2 mg. K_2O with varying amounts of stannous chloride and hydrochloric acid. If the intensity of the color is dependent only on the amount of K_2PtCl_6 in solution the ratios should all be 1.00. The ratios were checked by reading with the colorimeter cups set at three different heights.

c.c. HCl per 100 ml.	c.c. $SnCl_2$ per 100 ml.	Ratio		
		90 mm.	75 mm.	60 mm.
25	1	1.01	1.00	1.00
25	3	1.01	1.00	1.02
25	10	1.01	1.00	1.02
25	15	1.01	1.01	1.02
25	20	1.03	1.00	1.00*
25	25	1.02	1.01	1.05*
25	30	1.06	1.05	1.05*
25	40	1.07	1.07	1.07*
25	50	1.03	1.04	1.07*
0	5	Impossible to match tints		
10	5	1.00	1.00	1.02
35	5	1.01	1.01	1.00
50	5	1.06	1.08	1.05*
75	5	Impossible to match tints		

The samples marked with an asterisk were of different tint than the standard, in each case the tint of the samples being redder. It is evident that the intensity of the color is not dependent upon the amounts of stannous chloride or hydrochloric acid used within wide limits and that a wide range of amounts of these two reagents may be used in developing the color.

DISCUSSION

It was necessary to make certain modifications of Hill's method before it could be applied to soil extracts and waters. Hill advised adding concentrated sulphuric acid to the sample before evaporating and igniting in order to convert all of the potash present to the sulphate. This was done to decrease the possibility of loss of potash due to volatilization during ignition, the sulphate being less volatile than many other salts of potash likely to be present. However, this procedure also converts the salts of other metals present to sulphates, and it was found that upon precipitating the potassium chloroplatinate and taking up the residue with alcohol a very heavy residue of sulphates insoluble in alcohol was left. It is impossible to wash all of the excess platinum chloride out of this residue and such procedure always leads to very high results, often to errors of 200 and 300 per cent. However, magnesium, ferric, manganous and calcium chlorides are all fairly soluble in alcohol and are readily dissolved by the quantity of alcohol used to take up the residue. The solubility of sodium chloride in 95 per cent alcohol at 28° C. is 0.4 gram per 100 grams of solution, so up to 0.2 gram of sodium chloride will be dissolved. This is 30 to 150 times the amount of potassium chloride present in the sample. In practice we have found that if the bases present are converted to chlorides, practically all of the residue except the K_2PtCl_6 goes into solution and that the excess platinum chloride is readily washed out. It is necessary, however, to carry out the ignition of the sample at as low a temperature and for as short a time as possible to avoid losses due to volatilization of potassium salts.

A second modification of the original Hill method was necessary in the matter of the development of the color. According to Hill all that is necessary to develop the color is to add 3 c.c. of stannous chloride solution to the water solution of K_2PtCl_6 . We found that this leads to a wide range of tints and that often samples prepared in this way cannot be compared at all with the standard. However, the addition of a fairly large quantity of concentrated hydrochloric acid prevents cloudiness due to hydrolysis of the platinum salt and gives the same tint with all samples.

It seems probable that the increased accuracy of the modified Hill method over the Lindo-Gladding method is due to the fact that the residue of potassium chloroplatinate and other salts left after precipitation is much smaller in the case of the Hill method, allowing less opportunity for mechanical retention of platinum chloride. Moreover, the crystals of K_2PtCl_6 produced by the Hill method are very fine, due to the small amounts of potash present, while those produced by the Lindo-Gladding method are often quite coarse. Vürtheim (4) mentions that mother liquor containing platinum chloride may be occluded in large crystals of potassium chloroplatinate precipitated from strong solutions. Also, any impurity present in the residue on precipitation which is not dissolved by the alcohol or the ammonium chloride wash used in the Lindo-Gladding method will be weighed and cause high results, while impurities present in the Hill method, unless they be colored substances not reducible by stannous chloride (which type of substances do not normally occur in soils and waters) do not give rise to any error. It will be noted that all of these sources of error tend to give high results and that in

Tables I and II where colorimetric results are compared with gravimetric results, the latter are higher wherever the two methods fail to check.

It is desirable that the amount of K_2O in the sample taken for analysis be kept small. If the amount of K_2O is between 1 and 10 mg. the precipitate of K_2PtCl_6 will consist of very fine crystals which will offer little opportunity for mechanical retention or occlusion of platinum chloride. If a soil contains between 0.01 per cent and 0.10 per cent extractable K_2O a 100 ml. portion of extract is suitable. Otherwise, if possible, the amount of extract taken for analysis should be regulated so as to bring the amount of K_2O in the sample within these limits. However, most of the soils with which we have to deal contain amounts of extractable K_2O lying between 0.01 per cent and 0.10 per cent.

According to Seidell (5) the solubility of K_2PtCl_6 in 94.7 per cent alcohol at $14^\circ C.$ is 20 mg. per liter. Data for the temperature at which we work were not available; but the solubility at $25^\circ C.$ to $30^\circ C.$ would not be much greater. A sample containing 1.0 mg. of K_2O will give a precipitate of K_2PtCl_6 weighing 5.16 grams. If 50 c.c. of alcohol is used to take up the residue and wash and the solubility given by Seidell is assumed, 0.1 mg. of K_2PtCl_6 will be dissolved providing equilibrium is established. This would cause an error of 20 per cent. However, the rate of solution of K_2PtCl_6 in alcohol is very slow, so that if the K_2PtCl_6 is already crystallized out before the alcohol is added and washing be carried out under suction with small portions of alcohol, the error due to the dissolving action of the alcohol will be very small. The solubility of this salt increases rapidly as the concentration of the alcohol decreases, being 200 mg. per liter for 58.5 per cent alcohol. Therefore the alcohol used should be between 92 and 95 per cent. We have found in practice that using alcohol of this strength and following the procedure outlined no appreciable error is produced due to dissolving of K_2PtCl_6 .

SUMMARY

With some modification, the Hill method of colorimetric analysis for potash is suited to the analysis of soil extracts, soil percolates and irrigation waters.

This method has the following advantages over the Lindo-Gladding method for this type of analysis:

1. Requires less than one-fourth as much time for analysis.
2. Requires less of the analyst's time and attention.
3. Requires a smaller quantity of reagents and apparatus.
4. Gives greater accuracy without employing special refinements of procedure.

The method, when carefully applied, is capable of yielding results which are reasonably correct in the third significant figure, which seems to be the limit of accuracy permitted by colorimetric methods.

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Determination of the Ripeness of Cane by Means of Pre-Harvest Sampling

BY W.M. WOLTERS

SCOPE

The ripening of cane fields is controlled in part through correct regulation of cultural practices such as time of fertilizer application, amounts and kinds of fertilizers, and irrigation, in relation to the development of the cane plant, and the time of year that the fields are to be harvested. Through these measures the plant is helped to reach its maximum ripeness, especially through the difficult ripening months of the winter season. After the month of March the cane plant usually begins to ripen of its own accord. Climatic influences are the most significant factor over which we have no control.

Pre-harvest sampling, conducted on a systematic basis, is valuable not only as a guide to the sequence in which fields are to be harvested, but also in determining the effects of cultural practices, fertilization, irrigation and weather on the ripening of cane.

VALUE OF PRE-HARVEST SAMPLING

Through study and experience, a technique of sampling cane in the field has been developed to meet our conditions and it has been used with success as shown by the following data.

To illustrate: Thirty-nine out of 41 fields were sampled at periodic intervals in 1929. It was impossible to sample 2 fields correctly. Table I shows the average figures for the pre-harvest and field harvested samples (actual data).

TABLE I—1929 CROP

Samples	Brix	Pol'n	Purity	Cane	Per Cent Juice	
				Ratio	P ₂ O ₅	K ₂ O
Pre-harvest	18.69	16.83	89.09	7.39	.025	.128
Actual	18.56	16.25	87.55	7.74	.027	.143

Our sampling technique was improved upon for the 1930 crop and the results are shown in Table II. Thirty-seven out of 42 fields were sampled. It was impractical to sample the remaining 5 fields. The omission of certain fields from a sampling schedule is explained in later paragraphs.

TABLE II—1930 CROP

Samples	Brix	Pol'n	Purity	Cane	Per Cent Juice	
				Ratio	P ₂ O ₅	K ₂ O
Pre-harvest	18.25	16.14	88.44	7.74	.027	.099
Actual	18.19	16.09	88.40	7.74	.026	.110

Table III shows the results for the 1931 crop. It was possible to sample correctly all the fields (39) but the results were not in such close agreement as those of the 1930 crop due to more D 1135 cane being harvested in 1931 than in 1930.

TABLE III—1931 CROP

Samples	Brix	Pol'n	Purity	Cane Ratio	Per Cent Juice	
					P ₂ O ₅	K ₂ O
Pre-harvest	18.80	16.49	87.71	7.60	.024	.102
Actual	18.43	16.05	87.09	7.88	.026	.135

DIFFICULTIES IN SAMPLING CANE

The results in the preceding tables are considered to be very satisfactory considering the difficulties and odds against accuracy in this work. The sources of errors and the odds are enumerated below to show that it is a real task to present a true picture of the relative quality of the various fields of cane. It has been estimated that an average field of H 109 cane produces about 25,000 stalks of millable cane per acre and when 3 stalks are taken to represent an area of about 20 acres there are great odds against accuracy.

- (1) Odds against number of stalks.

Example: A 150-acre field would average 37,500,000 stalks of H 109.

This total number of stalks would be represented by 21 sample stalks.

- (2) Errors in the selection of representative sampling areas in a field.
- (3) Errors in the selection of representative sample stalks within these areas.
- (4) Unlike cane for comparison in that the pre-harvest cane consists of normal, sound stalks whereas harvested cane from the field includes cane in all stages of maturity and decay, degree of soundness, sucker growth and lala cane. This point is fully discussed further along in the paper.
- (5) Comparison of unburnt pre-harvest cane with the burnt harvested cane entering the factory.
- (6) Small-stalk canes of the D 1135 and P. O. J. 36 types are more difficult to sample than the H 109 type.
- (7) Effect of climatic factors on juice qualities during the harvest period of the field.
- (8) Errors in reading of the hydrometer or Brix spindle and polariscope.
- (9) Changing value of the factor used in translating the "Cuba A" mill analyses over to the commercial mill basis. This happens when conditions change for either mill.

PROBLEMS OF FIELD SAMPLING

Cane sampling has sometimes been called an art based only on the intelligence of those who take the samples. This art, however, may advantageously be placed on a systematic basis with a definite procedure as a result of careful study and experience, and it then becomes a technique. The pre-harvest sampling technique

employed at the Oahu Sugar Company, Ltd., and worked out by the author, has been proven to be successful and is described in the following paragraphs.

Originally, sampling consisted of carload lots of cane harvested wherever the railroad track happened to be in the field. Under this method samples could not be taken before the grinding season. They were not representative of the field and only showed the relative ripeness of the field at the point of sampling. Since it was proven here that 10 stalks of cane sampled at random next to the carload sampling area gave similar results in one-twelfth of the time and at a much lower cost, the carload sampling method was rapidly replaced by the systematic pre-harvest method which had since been considerably developed. (Note: Pre-harvest sampling was first started on this plantation in September, 1925.)

One of the outstanding problems is the correct sampling of irregular fields in order to show the average quality. Inaccessibility, with a resultant loss of time, offers another difficulty in field sampling in that all important points necessary for a true average of field conditions may not be covered. When these conditions are too severe, it is not advisable to sample. In addition to these difficulties are those reviewed under "Difficulties in Sampling Cane."

SAMPLING TECHNIQUE

In our sampling technique, the fields for the ensuing crop are arranged in the order of a tentative harvesting schedule which is determined by the management. Cane sampling of the respective fields starts in August for all except the group of short ratoon fields, and is conducted at monthly intervals until the harvest period of each field. Each field is sampled at about the same date of each succeeding month in order to give a proper time interval. If the sampling date falls within a week of the beginning of the harvest of the field in question, the sampling results are considered as final, otherwise an extra sample is taken a few days prior to the field harvest. Very often an extra sample is taken of several fields as a guide to "what field shall be harvested next." This is particularly true when a group of fields have been running close together in their juice qualities for some time, after which heavy showers of rain would tend to bring down the juice qualities of some fields faster than others.

By sampling our fields 4 months prior to the beginning of harvest, we are able to get 4 points on a curve to show the trend of ripening. This information can serve as a guide to the management in determining what changes, if any, should be made in the order of harvesting fields.

The number of representative sampling areas selected in a field is dependent on the size and uniformity of the field. Within every 15 to 25 acres of this field, a representative area for sampling, consisting of about 10 lines, is located from 75 to 100 feet from the edge of the field road, trail, supply ditch or any other type of boundary. Where spot irrigation is practiced, these sites are established deep enough into the field to avoid this unusual condition. Sampling sites are conveniently marked so that they can be readily located at subsequent periods of sampling. A new row of cane is sampled at each interval.

The sampling rows are divided into three sections and a stalk of cane is picked at random from the middle of each section, thus giving 3 stalks per row per site per field unit (15 to 25 acres). This method gives us a true average of the cane in the row. Through experimentation we have found that the end sections of a cane row have heavier cane but poorer juice while the middle section has lighter cane and better juice.

In selecting a stalk of cane, the sampler uncovers some of the trash at the bottom of the row and traces the stalk out to its leafy top to see that it is a normal, sound stalk, free of tassel and lalas. He then cuts it off flush with the bottom of the row, using a short keyhole saw, and tops it at a point similar to that done in the harvesting field. The stalks are cut in convenient lengths for dragging them out of the field.

The various areas are sampled until the entire field has been covered, after which the samples are taken to the mill to be measured, weighed and crushed. The total length and total weight are determined, which, divided by the number of stalks, give the average length and weight per stalk. The cane is crushed in a Cuba A mill and a representative sample of the extracted juice is taken to the laboratory for analysis. Sampling is done carefully and as rapidly as possible. During rainy weather the cane is wiped free of mud and moisture before it is crushed.

Correct selection of cane stalks is most important and is also difficult since there is such a great variation between them. Consistent results cannot be obtained unless great care is used in cutting the cane at the ground level and topping it at the same relative point. It has been proven through experimentation that the results can be altered by incorrect cutting and topping of cane. Stalks are found in various stages of maturity and ripeness and there is also a certain amount of defective cane due to various causes. Not knowing the proportion of these classes of cane stalks plus undetermined sucker growth, which affect cane yields and juice qualities, the best method is to select normal, healthy, non-tasseled stalks at random in the cane row as described in the foregoing paragraph. In this way, all the fields are placed on a common basis for relative comparison.

PRE-HARVEST DATA

Variation between the results of the final pre-harvest samples and final field analyses, provided that the correct technique has been followed in sampling, is attributable to such factors as: (1) dead, partly rotted or insect-infested cane, the amount of which varies according to field conditions and varietal characteristics; (2) sucker growth; (3) amount of tasseled stalks; (4) climatic influence in the interim between the pre-harvest sampling date and period of field harvesting; and (5) burnt cane versus unburnt cane.

The data on pre-harvest cane sampling is presented in reports which are in the following form, two examples of which are shown:

REPORT I

OAHU SUGAR COMPANY, LTD.

JUICE ANALYSES OF PRE-HARVEST CANE SAMPLES

Field 20			H 109—Long 4th Ratoon			1931 Crop		
Date	Brix	Pol.	Purity	%	%	Average	Average	Weight per Foot Pound
				P ₂ O ₅	K ₂ O	Length per Stalk	Weight per Stalk Pounds	
CUBA "A" MILL ANALYSES								
3/ 2/31	19.77	18.00	91.05	.020	.057	16.21'	9.00	0.56
2/15/31	19.50	17.73	90.92	.020	.068	15.52'	8.76	0.56
1/12/31	17.99	16.19	89.99	.015	.066	15.92'	9.26	0.58
12/ 5/30	17.13	14.89	86.92	.022	.076	15.48'	8.95	0.58
11/20/30	16.00	14.12	88.20	.015	.057	14.22'	7.43	0.52
10/27/30	14.70	11.80	80.27	.017	.063	13.59'	7.86	0.58
9/17/30	15.38	12.78	83.10	.0175	.090	12.00'	7.14	0.60

WAIPAHAU ANALYSES

Date	Brix	Pol'n	Purity	Cane Ratio	
				Cane	Ratio
3/ 2/31	19.77	17.50	88.52		7.12
2/15/31	19.50	17.23	88.36		7.27
1/12/31	17.99	15.74	87.49		7.97
12/ 5/30	17.13	14.47	84.47		8.89
11/20/30	16.00	13.72	85.70		9.27
10/27/30	14.70	11.47	78.03		11.94
9/17/30	15.38	12.42	80.42		10.67

REPORT II

OAHU SUGAR COMPANY, LTD.

JUICE ANALYSES OF PRE-HARVEST CANE SAMPLES

	Field 44	H 109—Long 4th	Ratoon	1932 Crop		
Date	Brix	Pol'n	Purity	Cane	% Standard	K ₂ O %
				Ratio	Glucose	Ripeness	Juice
CUBA "A" MILL ANALYSES						
9/14/31	16.55	14.40	87.01		1.10	52.4
8/18/31	16.41	14.15	86.25		0.93	60.8

COMMERCIAL MILL CONVERSION

Date	Brix	Pol'n	Purity	Cane Ratio	Age of Cane	Average Stalk		Weight per Ft. Cane Pound
						Length Feet	Weight Pounds	
9/14/31	16.55	14.00	84.59	9.18	16 Mos.	11.83	7.08	0.60
8/18/31	16.41	13.75	83.79	9.38	15 Mos.	10.98	6.08	0.55

Under Report I are the results of pre-harvest sampling for one of the fields of the 1931 crop to show the progress of cane ripening. The report shows the rela-

tive difference between the analyses of the Cuba A mill crushings and that of the commercial mill as determined by the correction factor. The factor which is used for our conditions in order to change the Cuba A mill juice over to our commercial mill basis is 97.2, i.e., 97.2 per cent of the Cuba A mill polarization gives an approximately correct figure for polarization to represent actual conditions. The Brix from the Cuba A mill is so close to the actual that a correction factor makes no difference. It will be necessary for each plantation to work out its own factor of correction. There is a steady improvement in the juice quality of the field from the time sampling was started till the harvest period of March 6-16, 1931, with one exception. The influence of weather along with the final irrigation of the field brought down the juice quality for the month of October. The statistics on stalks of cane are interesting in that they give one an idea of the quantity of cane in terms of growth. At time of harvest, the cane was $21\frac{3}{4}$ months old so that it is reasonable to believe the cane to be nearly 16 feet in length at an average weight of 0.56 pound per foot. The average weight per foot of H 109 cane for a five-year period of all classes of H 109 is 0.58 pound. None of the stalk statistics shown in Report I correlate with final cane yields because of the variation in the number and kind of stalks per line.

Beginning with the 1932 crop, the reports have been changed somewhat as shown in Report II. We have come to the conclusion that it is not necessary to show P_2O_5 per cent Brix any more since the figure is fairly constant for all classes of cane and fertilizer practices. Potash varies a great deal depending on variety and treatment of cane so it is interesting to know the relative amounts absorbed for different conditions. Age of cane at various periods of sampling has certain value. A new method of measuring relative juice quality is the factor called the "Standard of Ripeness" which was devised by H. W. Robbins, chief chemist of the Oahu Sugar Company. Standard of Ripeness is a more accurate means of measuring the real ripeness of a field from time to time. This is best explained by quoting from Mr. Robbins' report entitled: "The Quality of Cane and Cane Ripening."

When making a study of cane quality and ripening it is necessary to have a standard that will serve for comparison of different varieties of cane, and of cane grown under all conditions. The cane ratio is the measure most generally used in estimating the quality of cane. This ratio is calculated from the sucrose content of the cane and the purity of the cane juice, and is a ratio of quantity. When used with a known weight of cane it indicates quality. When the weight of the cane is not known, as in pre-harvest juice sampling, it cannot correctly be used as an indication of quality. The sucrose content of the cane is influenced by the water content, resulting in a high or low cane ratio, so that the cane ratio may be high or low due to more or less water in the cane.

The purity of the juice of the cane, being the pol expressed in percentage of the total solids in solution, is not influenced by the water content of the cane. Purity, however, being on the basis of solids in solution can be influenced by the nature of the solids other than sucrose. When the cane is approaching ripeness the sucrose content of the juice is high while that of the non-crystallizable sugars (glucose) is low. Ordinarily this condition results in a high purity, indicating ripeness. If, however, this cane should contain a large amount of solids in solution not sugars, the purity would be lower and not indicate the condition of ripeness. An example of this is D 1135 cane, the juice of which contains quite generally twice as much potash in solution as the juice of H 109. Our

records show the non-sugars of D 1135 to be 50 per cent more than that of H 109, and other varieties somewhat higher. High juice purities at maximum ripeness cannot be expected of these canes. Our records show also that there are fields on the plantation that produce cane with juice of high non-sugar content as compared with the same variety of cane in other fields.

For the purpose of making comparisons of ripeness the ratio of glucose to polarization is useful. A standard ratio may be used. We have taken a ratio of 25 equal to a standard ripeness of 100. It is assumed that any system of ripening cane will affect this ratio, while the ratio of non-sugars to pol is due to other factors. The non-sugars are taken as the difference between sum of the pol and the glucose, and the total solids in solution as determined by the Brix hydrometer. The figures for non-sugars include the errors of difference between pol and sucrose and the differences between true solids and Brix solids. As these differences are somewhat constant, the figure has some value in a study of this nature.

Examples of this method of estimating the ripeness of cane are given from the field records of the crop of 1931 and the average of all fields of the crop of 1930.

Crusher Juice				Per 100 Brix			Glucose			Cane
Field	Variety	Brix	Pol	Purity	Pol	Glucose	Non-Sugars	Pol	Standard Ratio	
3-B	D 1135	17.12	14.25	83.2	83.2	4.6	12.2	18.09	72.4	8.92
52	H 109	17.50	15.38	87.9	87.9	4.5	7.6	19.53	78.1	7.89
53	H 109	16.80	13.77	82.0	82.0	7.2	10.8	11.39	45.6	9.38
45-A	H 109	19.40	17.85	92.0	92.0	2.5	5.5	36.80	147.2	6.73
Ave. 1930		18.19	16.09	88.4	88.4	3.6	8.0	24.55	97.5	7.92

These are extremes of juice purities and the standard ripeness figure follows the purity, but not in the same proportion.

Below is given the application of this method to two varieties of cane grown on adjoining plots of .40 acre area each at the H. S. P. A. Waipio substation. The two canes were planted, irrigated, fertilized and harvested at the same time.

Crusher Juice				Per 100 Brix			Glucose		
Variety	Brix	Pol	Purity	Pol	Glucose	Non-Sugars	Pol	Standard Ratio	Ripeness
H 109	20.01	17.53	87.6	87.6	4.4	8.0	19.92	79.7	
Y. Caledonia	19.45	15.78	81.1	81.1	5.0	13.9	16.22	64.9	

This illustrates the effect on the juice of a similar practice of growing cane when applied to two varieties. The glucose determinations and the non-sugars, by difference, give some explanation for the juice of Yellow Caledonia being so much lower than that of H 109.

SUMMARY

PRE-HARVEST JUICE SAMPLING

Object:

To secure such samples from a field that a reasonably accurate prediction may be made of the average quality of cane when harvested.

Number and Location of Sampling Areas:

The number of sampling areas and their locations must be such that in each group of sample stalks from that field there will be a proportionate number from

each class of soil and terrain, i.e., light or heavy soils, pali, bottom, slope or flat. Sampling areas should be at least 100 feet from edge of field, or any field road, trail or ditch.

Size of Sampling Area:

Each sampling area should have about 10 lines. This should represent an area not larger than 25 acres or less than 15 acres, depending upon conditions.

Marking of Sampling Areas:

Each sampling area should be clearly marked so that it may be found readily when samples are to be taken.

Taking Samples:

Three sound sticks of cane should be taken from one row in each sampling area for each sample. Avoid extreme ends of row. Take one stick at each of three points in the line. Cut cane cleanly at or below ground and always top sticks at same relative point; this is important. Avoid suckers or tasseled stalks. Keep the sample group from each field separate and clearly mark. Remember that the results of the entire work depend on the care used in sampling and the validity of the group samples as representing the field.

Preparation for Milling Sample:

Sample stalks are weighed and measured to give average length and weight per foot. In wet weather, stalks should be wiped clean.

Milling Sample:

Samples are milled in a small Cuba A mill, using care to see that juices are accurately separated. Juice samples should be taken frequently and analyzed as soon as possible.

Conversion Factor:

A conversion factor is necessary to translate the results of the sample into terms of the lower purity juice which results from commercial mill work. This factor will have to be developed from experience for each plantation. (Oahu factor for purity is 97.2 per cent. Brix need not be corrected.)

Results of Sampling Fields:

After six years of development of the technique of sampling, there is a high degree of correlation between the last field sample and the quality of the cane when harvested.

Temperature, Rainfall and Sunshine Data of Hawaiian Sugar Plantations

COMPILED BY U. K. DAS

1. Foreword.
2. Climatic characteristics of the Hawaiian Islands.
3. Temperature data :
 - Annual temperature.
 - Seasonal temperature.
 - Monthly average temperature.
 - Mean daily range of temperature.
 - Extremes of monthly temperature.
 - Temperature departures from average (1905-1930).
4. Rainfall data :
 - Normal monthly rainfall.
 - Extremes of monthly rainfall.
 - Rainfall departures from normal (1905-1930).
5. Sunshine data.

FOREWORD

An intensive study of the factors in sugar production must take into consideration the part played by weather conditions: temperature, sunshine, rainfall, etc. There is as yet very little systematic and organized knowledge available of the climate of our sugar plantations. Such knowledge would appear to be the more needed at this time, for a dispassionate study of the relation of our cultural practices to the increased yields of recent years must start by eliminating the effects of changed weather conditions.

In this paper, we have brought together in a convenient form some climatic data for the last 26 years (1905-1930) of the sugar plantations of the Territory.

The data are far from being adequate at present, but it is hoped that this paper will stimulate interest in the recording and study of weather data, so that in years to come we shall know quite as much about the effects of weather conditions on sugar production as we do of the effects of fertilizers, irrigation water, etc.

Special thanks are due J. F. Voorhees, of the U. S. Weather Bureau at Honolulu, for placing at our disposal the complete files from which most of the original data were taken, and also for valuable help and criticism.

We would appreciate our attention being drawn to errors and omissions in this text.

CLIMATIC CHARACTERISTICS OF THE HAWAIIAN ISLANDS

An excellent account of the climatic characteristics of these islands may be found in the "Summary of the Climatological Data" for the Hawaiian section published by the U. S. Weather Bureau in 1918, copies of which publication are available at the office of the Weather Bureau at Honolulu.

The following extracts are taken from the said publication:

The rainfall of the Hawaiian Islands belongs to a simple type, being due mostly to the forced ascent of the northeast trades by the mountains they encounter. Usually, therefore, heavy rains fall on the windward slopes. This condition, however, is reversed during the prevalence of the so-called kona storms.

Temperature is a much simpler factor to study than precipitation, depending almost entirely as it does on elevation, although affected in a minor way by the slope and exposure to the wind. The range of mean monthly temperature from summer to winter in the lower levels throughout the island is slight and simple of analysis, while the drop in temperature from sea level to the highest elevations corresponds closely to what might be expected of temperature gradients in the tropics (Temperature decrease of 1° F. for each 300 ft.).

The outstanding features of Hawaiian climatology are the remarkable differences in the quantity of precipitation gaged in adjacent areas, the tenaciousness of the trade winds through all seasons and over all islands of the group (aside from a limited area leeward of Haleakala and over the kona districts of Hawaii), and the persistently equable temperature which passes through the cycle of seasons devoid of extremes. The abundant sunshine, especially over the leeward slopes, and the lack of tropical storms, known elsewhere in the tropics as typhoons or hurricanes, add to the desirability of the climate from the standpoint of recreation and pleasure as well as the more practical pursuits of life.

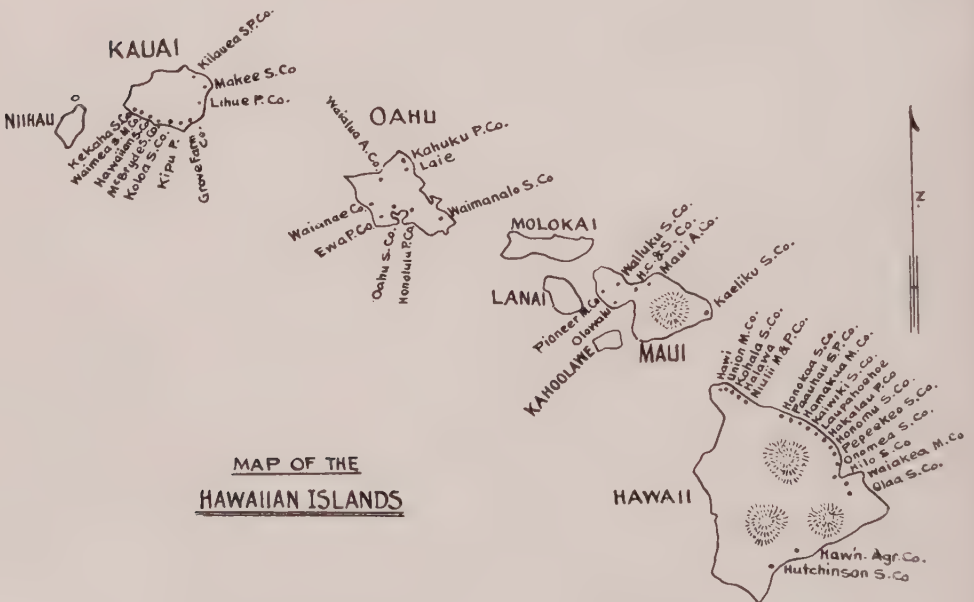


Fig. 1. Map showing the location of the sugar plantations.

SUMMARY OF CLIMATIC DATA OF THE SUGAR PLANTATIONS

Weather Station	Elevation in Feet	Annual Mean Max. Temp. Fahr.	Annual Mean Min. Temp. Fahr.	Mean Daily range of Temp.	Mean Annual Rainfall
OAHU					
Ewa Mill	50	83.0°	64.6°	18.4	20.75
Kahuku	25	80.9	68.0	12.9	37.62
Waialua	30	82.6	63.7	18.9	30.76
Waianae	6	85.2	66.4	18.8	19.78
Waimanalo	25	81.7	68.9	12.8	43.83
Waipahu	200	82.5	65.9	16.6	24.31
MAUI					
Hana	200	80.3	67.5	12.8	75.21
Kaanapali	12	84.8	65.8	19.0	18.30
Lahaina	30	....	....	....	12.13
Puunene	..	82.9	66.8	....	....
Wailuku	206	81.4	67.1	14.3	28.94
KAUAI					
Eleele	150	81.2	66.3	14.9	29.63
Grove Farm	200	....	....	....	48.13
Kealia	14	81.7	67.5	14.2	39.91
Kekaha	8	....	....	....	22.28
Kilauea	342	79.7	65.8	13.9	68.72
Koloa	241	79.8	66.5	13.3	64.17
Lihue	200	80.6	65.5	14.9	53.17
Makaweli	140	83.2	66.3	16.8	22.81
HAWAII					
Hakalau	200	78.9	65.8	13.1	147.04
Hilo	40	79.8	65.3	14.5	141.03
Honokaa Mill	461	80.2	64.1	16.1	78.48
Kohala	309	79.6	65.6	14.0	58.56
Naalehu	650	....	....	....	43.14
Niulii	85	....	....	....	61.95
Olaa Mill	225	81.8	63.1	16.7	141.06
Ookala	400	79.8	65.1	13.9	118.69
Paauhau	400	....	....	....	69.70
Paauilo	400	....	....	....	94.89
Pahala	850	81.1	61.4	19.7	44.26
Papaikou	250	....	....	....	182.87
Pepeekeo	100	79.8	65.8	14.0	128.24

TEMPERATURE DATA

The records of temperature from 1905-1930 are available for only 23 plantations of the Territory.

The data are presented as maximum or minimum temperature, for our studies indicate that in the understanding of the relation of cane growth to temperature, the maximum and the minimum temperatures are better guides than the mean temperature.

Annual Mean Temperature:

Table A (Fig. 3) gives the annual mean maximum and annual mean minimum temperatures of the different stations. It will be noted that in general the leeward plantations are warmer than the windward plantations.

Annual Mean Maximum And Mean Minimum Temperature

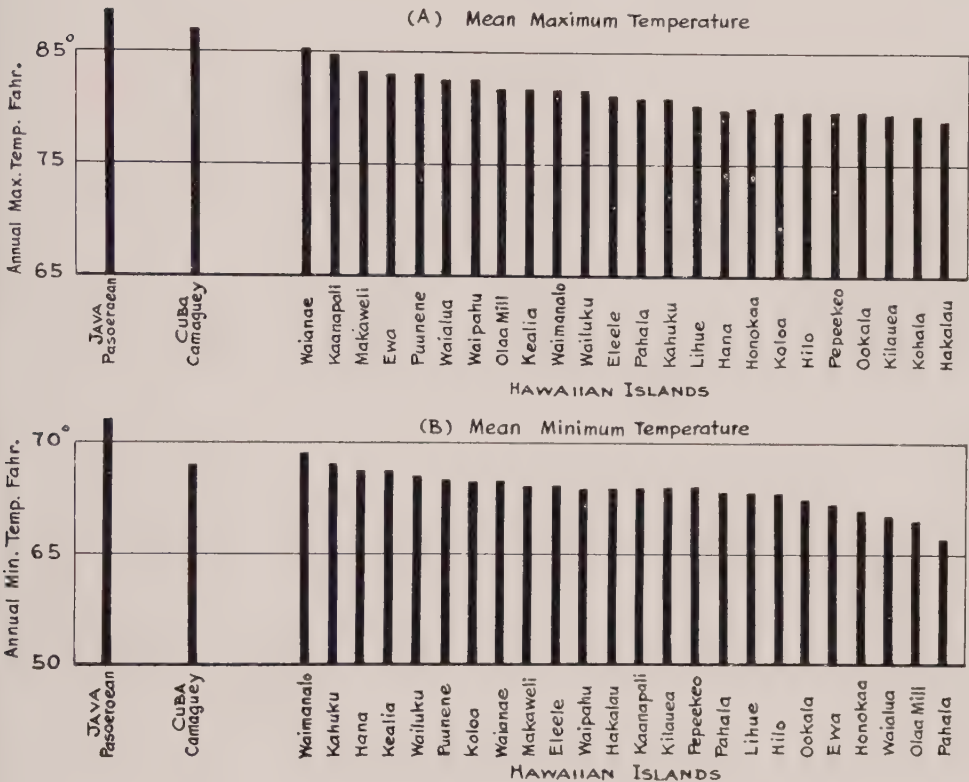


Fig. 3

Seasonal Temperature:

Table B (Fig. 4) shows the seasonal temperatures, arranged in the descending order of warmth. Seasonal means have been computed by taking January, February and March as the winter months, April, May and June as the spring months, and so on; for, in these islands, January, February and March are the coldest months, December being warmer than March. The seasonal temperatures of Java and Cuba are given for the sake of comparison.

Fig. 4 brings out some interesting differences between the plantations. Some places are comparatively warm or cold throughout all the seasons, while others are warm in some seasons and cold in others. For example—Ewa Mill (Fig. 4-A) is about the fourth warmest plantation throughout the four seasons, while Olaa mill is third warmest in winter, but only twelfth warmest in summer. Hakalau, on the other hand, is uniformly the coldest of all the plantations recorded herein

If we compare the temperature of Java and Cuba with that of our plantations (Fig. 3) we will notice a great difference. This difference is of even greater significance than is apparent. If we assume that sugar cane grows little or none at all below a mean maximum temperature of 65° , then we see that the "active" temperature (i.e., temperature over 65°) of Waianae—our warmest plantation—is only 87 per cent of Java temperature. Table C gives the annual mean maximum temperatures of Hawaiian plantations calculated as percentages of Java temperature.

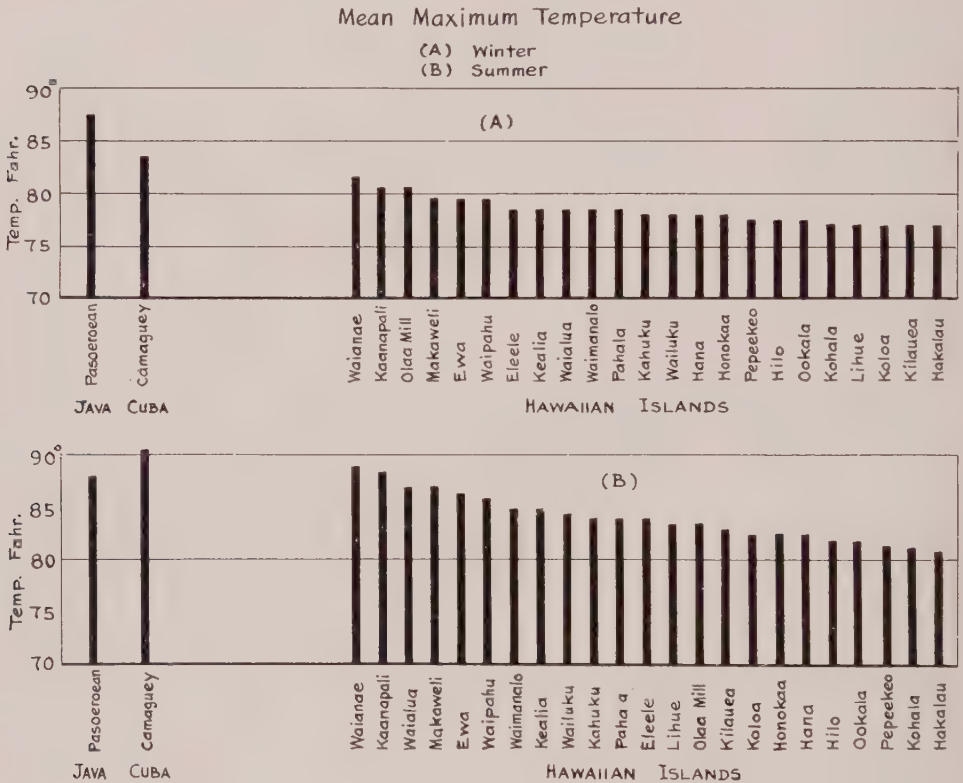


Fig. 4-A

Monthly Average Temperatures:

Table D gives the average mean maximum and average mean minimum temperatures by months. Table E shows the departures from the average of each month of 1905-1930. It is believed that the presentation of the temperature data as departures from the average rather than in absolute figures will facilitate the study of the relation of temperature to cane growth or sugar production. Should it be desired to find the temperature of any month, it can easily be done by adding the departure for the month in question to the average of that month.

There are several ways in which the tables could be made use of. Plantations may find it of advantage to plot the monthly temperatures for each crop on a wall chart similar to Fig. 5. This chart will show at a glance whether the weather

conditions have been favorable or otherwise for cane growth, whether this year's crop should be behind or ahead of last year's, etc. It will further be of assistance in estimating yields, in arriving at decisions regarding particular field culture.

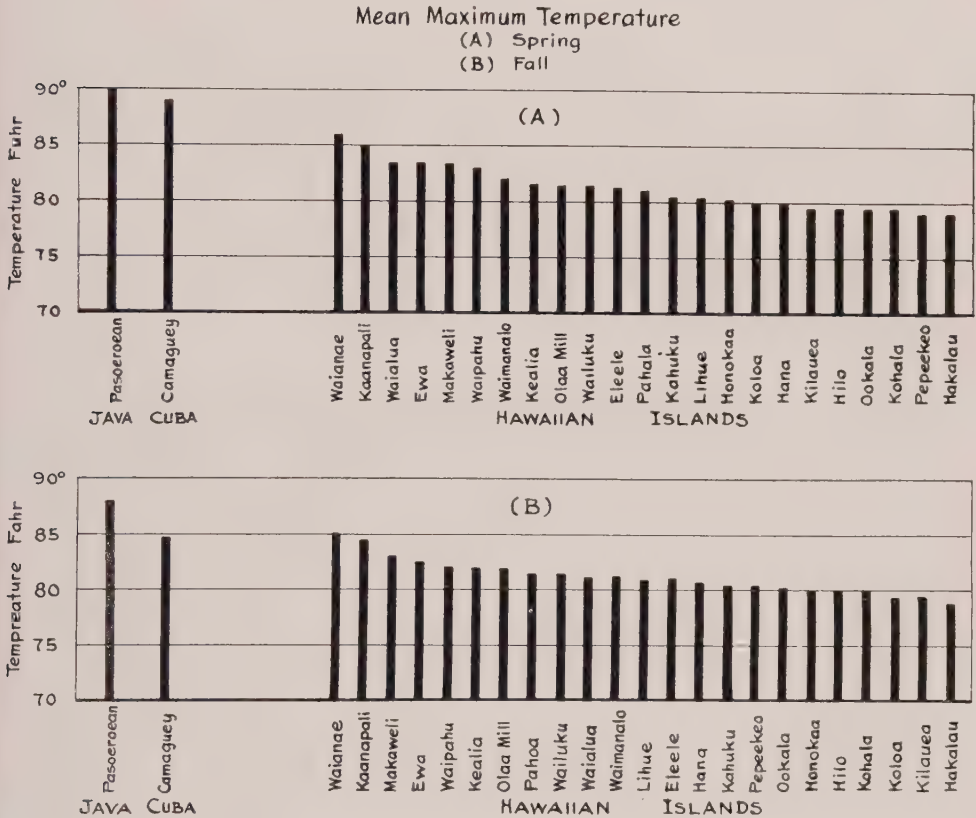


Fig. 4-B

We feel that the great significance of temperature changes to sugar production is not sufficiently realized by all the plantations—possibly because the temperature differences are not as apparent as the difference in the amount of rainfall from one season to another. While we are likely to notice a difference of 2 to 3 inches in rainfall, we hardly notice a difference of 2° to 3° in temperature. Yet in many cases, this imperceptible, but none the less significant, difference in temperature may influence our crop production to a far greater degree than the difference in rainfall.

Many growth studies conducted by the plantations and by the Experiment Station have demonstrated the close relation between temperature and cane growth. Our weather studies have shown clearly that the observed relation between temperature and cane growth can explain the fluctuations in yield per acre of the plantation crops as well. Fig. 6 shows very clearly the differences in temperature between the years of high yield and years of low yield of one of our typical unirrigated plantations.

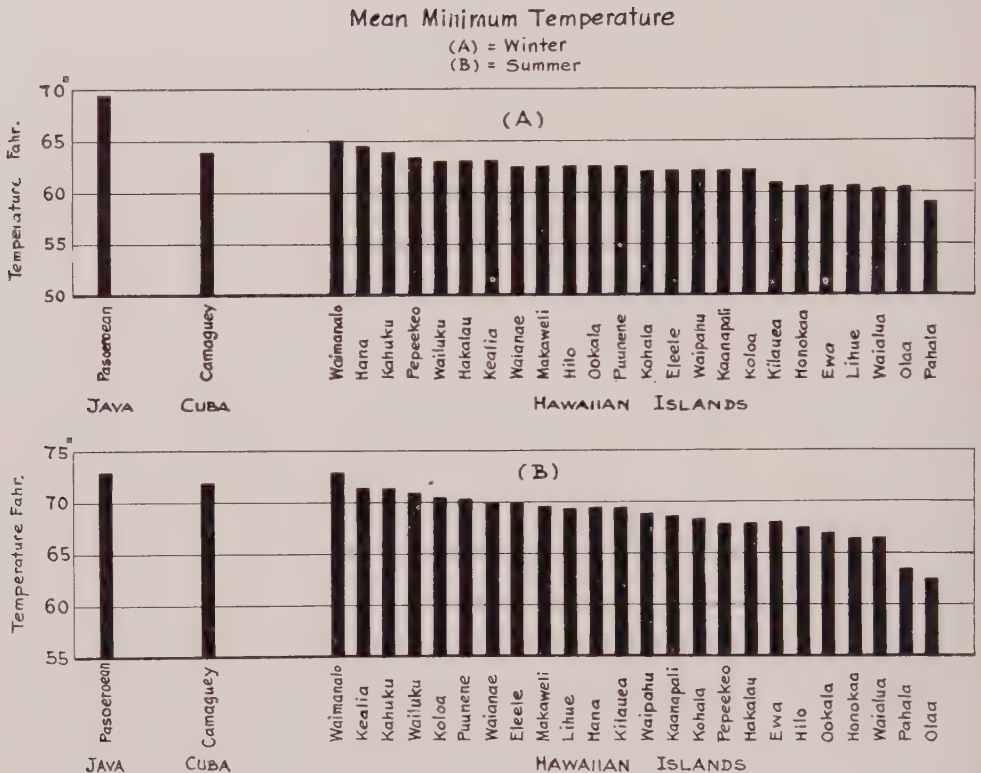


Fig. 4-C

Our studies have further shown that the temperature conditions in the first season are of greater importance than at any other subsequent period, probably because it is in the first season that the canes are growing, by nature, at a fast rate and that it is in the first season that the stand is being established. It is of great interest to note that the recent record yields of three of our typically well-irrigated plantations were associated with record temperatures in the first season.

Ewa had its record yield per acre in 1925. The mean maximum temperature in the fall months of 1923 (i.e., in the first season) were the highest on record. Oahu Sugar Company's record yield in 1928 was preceded by record temperature in the fall months of 1926 and the winter of 1927; Waialua's record yield of 1929 was similarly preceded by record temperatures in the fall months of 1927.

There are other information of practical benefit that we can gather from a close study of the temperature data. What, for instance, is the relation between temperature changes and periodic infestation of insect pests or fungus diseases? We hear of typical eye spot weather—are there typical weathers for other diseases as well? Again, a progressive plantation may want to take advantage of warm growing weather by applying more fertilizer or more water to the field, how will it know except by close study of the temperature data that one month of high temperature is likely to be followed by one or more months of high tem-

perature? Indeed, a casual study of the tables does show that warm and cold months generally come together in periodic fluctuations.

These introductory notes are mainly written in answer to oft-repeated questions—"Of what use are all these weather data?" "We can't do anything about our weather." Surely not, but by studying our weather we may know more about its ways and when the good weather comes we shall know and take advantage of it, and when the weather is against us, then also we shall know of it and know why our yields decrease and thus save ourselves unnecessary worry. We believe very strongly that plantations will find it of practical benefit to record weather data and make intelligent use of it.

A word of caution is necessary against the limitations of the data presented herein. We have only one weather station representing a plantation. The data from this one station may not apply to the whole plantation because of local differences in the different sections of its lands.

RANGE OF TEMPERATURE

Table F gives the mean daily range of temperature from 1905-1930 (range of temperature is equal to the difference between the average daily maximum and average daily minimum temperature). In Fig. 7 the plantations are arranged in descending order of their annual daily range of temperature.

Our previous studies indicate that range of temperature has a close relation to juice quality and possibly to cane production.* It will be noted in Fig. 7 that the plantations noted for poor juices have generally a low daily range of temperature.

EXTREMES OF TEMPERATURE

Table G gives the monthly extremes of temperatures for the years 1905-1930. These extremes are of interest in that they indicate how high or low a temperature we may expect in a particular month and what this difference means in terms of cane growth or sugar yield.

It will be noted that some plantations are more subject to extreme fluctuations than others. Waimanalo, for instance, has about the same extremes of mean maximum temperature in August as Ewa, but the average mean maximum of Ewa for that month is 1.4° higher than Waimanalo's.

* There are reasons to believe that the positive correlation between daily range of temperature and juice quality holds true only within certain temperature limits. Under conditions of extreme maximum or minimum temperature the normal physiological processes may be greatly disturbed. Under those limiting conditions, range of temperature alone may fail to account for the quality of juice.

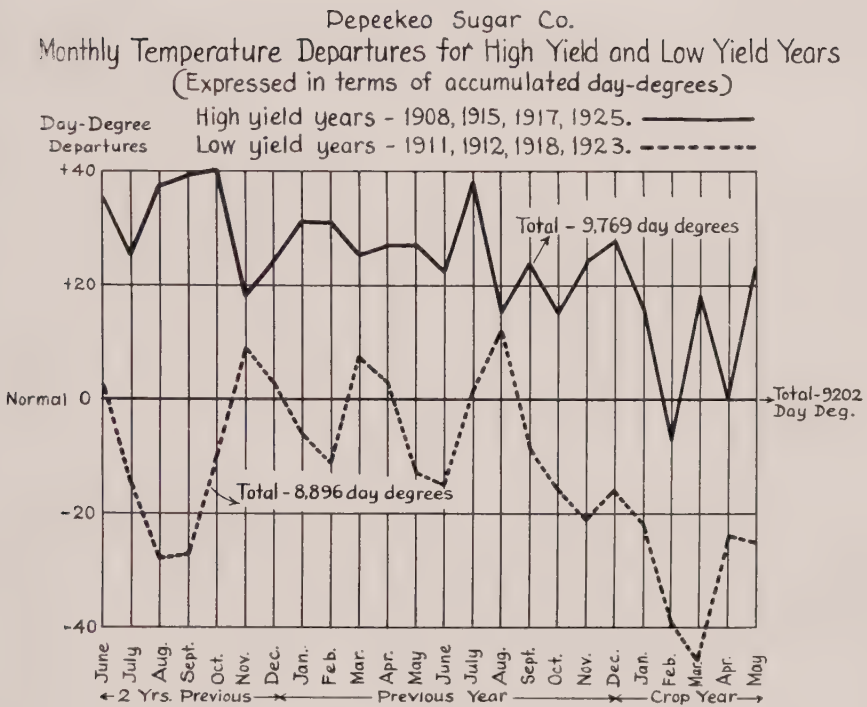


Fig. 6

Plantations Arranged In Descending Order
Of Daily Range Of Temperature

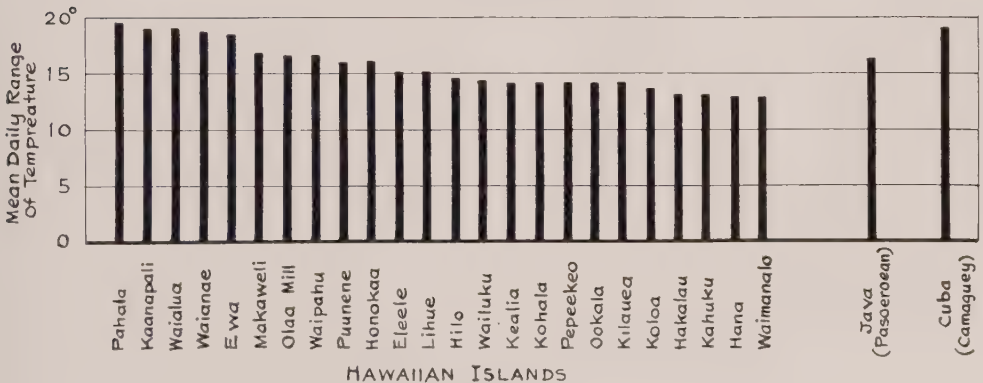


Fig. 7

TABLE A

Annual Mean Maximum and Mean Minimum Temperatures

Station	Mean Maximum Temperature	Station	Mean Minimum Temperature
Waianae	85.2	Waimanalo	68.9
Kaanapali	84.8	Kahuku	68.0
Makaweli	83.2	Hana	67.5
Ewa	83.0	Kealia	67.5
Puunene	82.9	Wailuku	67.1
Waialua	82.6	Puunene	66.8
Waipahu	82.5	Koloa	66.5
Olaa Mill	81.8	Waianae	66.4
Kealia	81.7	Makaweli	66.3
Waimanalo	81.7	Eleele	66.3
Wailuku	81.4	Waipahu	65.9
Eleele	81.2	Hakalau	65.8
Pahala	81.1	Kaanapali	65.8
Kahuku	80.9	Kilauea	65.8
Lihue	80.6	Pepeekeo	65.8
Hana	80.3	Kohala	65.6
Honokaa	80.2	Lihue	65.5
Koloa	79.8	Hilo	65.3
Hilo	79.8	Ookala	65.1
Pepeekeo	79.8	Ewa	64.6
Ookala	79.8	Honokaa	64.1
Kilauea	79.7	Waialua	63.7
Kohala	79.6	Olaa Mill	63.1
Hakalau	78.9	Pahala	61.4
Java (Pasocroean)	88.3	Java (Pasocroean)	72.1
Cuba (Camaguey)	86.8	Cuba (Camaguey)	67.9

TABLE B-I
Seasonal Mean Maximum Temperature—Plantations Arranged in Descending Order of
Temperature

Station	Winter Temperature	Station	Spring Temperature	Station	Summer Temperature	Station	Fall Temperature
Hawaiian Islands							
Waianae	81.3	Waianae	85.4	Waianae	89.0	Waianae	85.1
Kaanapali	80.6	Kaanapali	85.0	Kaanapali	88.8	Kaanapali	84.6
Olaa	80.6	Waialua	83.6	Waialua	86.9	Makaweli	83.1
Makaweli	79.5	Ewa	83.5	Makaweli	86.8	Ewa	82.6
Ewa	79.4	Makaweli	83.3	Ewa	86.5	Waipahu	82.1
Waipahu	79.1	Waipahu	82.9	Waipahu	85.8	Kealia	81.9
Eleele	78.6	Waimanalo	81.9	Waimanalo	85.2	Olaa	81.8
Kealia	78.6	Kealia	81.5	Kealia	84.9	Pahala	81.4
Waialua	78.5	Olaa	81.5	Waialua	84.5	Waialua	81.4
Waimanalo	78.4	Waialua	81.4	Waialua	84.1	Waialua	81.3
Pahala	78.4	Eleele	81.3	Pahala	83.9	Waimanalo	81.3
Kahuku	78.2	Pahala	80.8	Eleele	83.8	Lihue	81.2
Waialua	78.1	Kahuku	80.7	Lihue	83.7	Eleele	81.1
Hana	78.0	Lihue	80.3	Olaa	83.4	Hana	80.8
Honokaa	77.8	Honokaa	80.3	Kilauea	82.8	Kahuku	80.5
Pepeekeo	77.7	Koloa	79.8	Koloa	82.6	Pepeekeo	80.5
Hilo	77.5	Hana	79.8	Honokaa	82.6	Ookala	80.3
Ookala	77.5	Kilauea	79.7	Hana	82.5	Honokaa	80.2
Kohala	77.3	Hilo	79.7	Hilo	82.0	Hilo	80.1
Lihue	77.2	Ookala	79.5	Ookala	82.0	Kohala	79.9
Koloa	77.0	Kohala	79.4	Pepeekeo	81.7	Koloa	79.7
Kilauea	76.9	Pepeekeo	79.2	Kohala	81.7	Kilauea	79.4
Hakalau	76.3	Hakalau	78.8	Hakalau	81.1	Hakalau	79.2
Cuba (Camaguey)	83.5	Cuba (Camaguey)	89.0	Cuba (Camaguey)	90.5	Cuba (Camaguey)	84.5
Java (Paseroean)	87.5	Java (Paseroean)	90.0	Java (Paseroean)	88.0	Java (Paseroean)	88.0

TABLE B-II

Seasonal Mean Minimum Temperatures—Plantations Arranged in Descending Order of Temperature

Station	Winter Temperature	Station	Spring Temperature	Station	Summer Temperature	Station	Fall Temperature
Hawaiian Islands							
Waimanalo	65.0	Waimanalo	68.9	Waimanalo	72.8	Waimanalo	68.9
Hana	64.6	Kahuku	68.4	Kealia	71.6	Kahuku	68.2
Kahuku	64.0	Kealia	68.0	Kahuku	71.5	Hana	67.9
Pepeekeo	63.3	Hana	67.6	Wailuku	70.8	Kealia	67.5
Wailuku	63.1	Puunene	67.5	Koloa	70.5	Wailuku	67.2
Hakalau	62.9	Wailuku	67.3	Puunene	70.3	Puunene	66.6
Kealia	62.8	Koloa	66.9	Waianae	70.0	Waianae	66.4
Waianae	62.7	Waianae	66.7	Eleele	69.9	Eleele	66.4
Makaweli	62.6	Eleele	66.5	Makaweli	69.8	Koloa	66.4
Hilo	62.6	Makaweli	66.4	Lihue	69.7	Makaweli	66.4
Ookala	62.6	Kaanapali	66.4	Hana	69.6	Pepeekeo	66.1
Puunene	62.5	Lihue	66.2	Kilauea	69.4	Hakalau	66.1
Kohala	62.5	Kilauea	66.0	Waipahu	69.2	Waipahu	65.9
Eleele	62.3	Waipahu	66.0	Kaanapali	68.8	Kilauea	65.9
Waipahu	62.3	Hakalau	65.8	Kohala	68.6	Kohala	65.8
Kaanapali	62.2	Pepeekeo	65.5	Pepeekeo	68.2	Ookala	65.7
Koloa	62.1	Kohala	65.5	Hakalau	68.2	Kaanapali	65.6
Kilauea	61.9	Hilo	65.3	Ewa	68.1	Hilo	65.5
Honokaa	61.2	Ewa	64.8	Hilo	67.7	Lihue	65.2
Ewa	61.0	Ookala	64.7	Ookala	67.2	Ewa	64.6
Lihue	60.7	Honokaa	64.2	Honokaa	66.7	Honokaa	64.2
Waialua	60.5	Waialua	64.0	Waialua	66.7	Waialua	63.8
Olaa	60.3	Olaa	62.3	Pahala	63.5	Olaa	63.4
Pahala	58.8	Pahala	61.3	Olaa	62.3	Pahala	62.4
Java (Paseroean)	69.4	Java (Paseroean)	72.3	Java (Paseroean)	73.8	Java (Paseroean)	72.8
Cuba (Camaguey)	63.9	Cuba (Camaguey)	69.6	Cuba (Camaguey)	74.6	Cuba (Camaguey)	68.6

TABLE C

Annual Mean Maximum Temperature of Hawaiian Plantations Compared to the
Temperature of Pasoeroean, Java

Station	Annual Mean Temperature	Active Temperature*	Per Cent of Java Temperature
Java (Pasoeroean)	88.3	23.3	100
Cuba (Camaguey)	86.8	21.8	93
Hawaiian Islands			
Waianae	85.2	20.2	87
Kaanapali	84.8	19.8	85
Makaweli	83.2	18.2	78
Ewa	83.0	18.0	77
Puunene	82.9	17.9	77
Waialua	82.6	17.6	76
Waipahu	82.5	17.5	75
Olaa	81.8	16.8	72
Kealia	81.7	16.7	72
Waimanalo	81.7	16.7	72
Wailuku	81.4	16.4	71
Eleele	81.2	16.2	70
Pahala	81.1	16.1	69
Kahuku	80.9	15.9	68
Lihue	80.6	15.6	67
Hana	80.3	15.3	66
Honokaa	80.2	15.2	65
Koloa	79.8	14.8	63
Hilo	79.8	14.8	63
Peppeekeo	79.8	14.8	63
Ookala	79.8	14.8	63
Kilauea	79.7	14.7	63
Kohala	79.6	14.6	62
Hakalau	78.9	13.9	60

* "Active" temperature is equal to the number of degrees above 65° F.

TABLE D-I

Average Mean Maximum Temperature by Months													
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Oahu—													
Ewa	78.6	79.6	79.9	81.6	83.7	85.3	86.2	86.8	86.6	85.2	82.5	80.2	83.0
Kahuku	77.8	78.7	78.1	78.9	80.7	82.5	83.7	84.0	84.6	83.8	81.2	79.6	81.1
Waialua	77.7	78.5	79.3	81.1	83.8	85.9	87.1	87.2	86.4	84.2	81.0	78.8	82.6
Waiānae	80.1	81.2	82.0	83.5	85.5	87.1	88.8	89.4	88.7	87.4	85.1	83.0	85.2
Waimanalo	77.6	78.6	78.9	79.6	82.3	83.9	84.9	85.4	85.4	84.3	81.3	78.6	81.8
Waipahu	78.1	79.3	79.9	80.9	83.2	84.5	85.4	86.0	86.0	84.6	82.1	79.7	82.5
Maui—													
Hana	77.8	78.4	77.8	78.2	80.1	81.2	82.0	82.4	83.1	82.5	80.6	79.2	80.3
Kaanapali	79.9	80.7	81.3	82.3	85.6	87.2	88.3	89.2	88.9	87.6	84.5	81.6	84.8
Puunene	78.0	79.6	80.0	81.4	84.1	85.3	86.1	86.1	86.1	85.1	82.7	79.9	82.9
Wailuku	77.6	78.3	78.5	79.5	81.6	83.1	83.9	84.7	85.0	83.9	81.3	78.9	81.4
Kauai—													
Eleele	77.8	79.0	79.1	79.6	81.7	82.6	82.9	84.4	84.0	83.5	81.0	78.8	81.2
Kealia	78.2	78.8	78.7	79.8	81.6	83.1	84.3	85.0	85.3	84.1	81.8	79.8	81.7
Kilauea	76.4	77.4	76.8	77.8	79.9	81.5	82.4	82.9	83.0	81.7	79.1	77.3	79.7
Koloa	76.2	77.4	77.5	78.3	80.0	81.2	81.9	82.7	83.2	82.2	79.5	77.3	79.8
Lihue	76.9	77.3	77.5	78.3	80.4	82.2	83.3	83.9	84.0	82.6	79.8	78.1	80.4
Makaweli	78.7	79.8	80.0	81.4	83.4	85.1	86.4	87.2	86.7	85.4	82.7	80.7	83.1
Hawaii—													
Hakalau	76.1	76.5	76.2	77.3	79.1	80.0	80.7	81.3	81.4	80.8	79.1	77.7	78.9
Hilo	77.3	77.7	77.5	78.1	80.0	80.9	81.8	82.2	82.3	81.7	80.1	78.6	79.8
Honokaa	77.2	77.9	78.2	78.6	80.4	82.3	82.0	82.7	83.1	82.3	80.2	78.0	80.2
Kohala	77.2	77.3	77.4	77.7	79.5	80.7	81.2	81.7	82.1	81.8	79.8	78.0	79.5
Olaa	79.8	81.1	80.9	80.4	81.6	82.7	83.2	83.4	83.7	83.4	81.6	80.4	81.8
Ookala	77.3	77.4	77.7	77.9	79.5	81.2	81.6	82.1	82.2	82.0	80.3	78.6	79.8
Pahala	78.2	78.6	78.6	79.7	80.7	81.9	83.7	84.0	84.0	83.0	81.4	79.8	81.1
Pepeekeo	77.5	78.0	77.6	77.9	79.4	80.2	81.3	81.9	81.8	82.0	80.6	78.9	79.8
Java (Pasoroean)	87.6	87.6	87.8	88.3	88.3	87.8	87.2	87.8	89.2	90.3	89.8	88.5	88.3

TABLE D-II

Average Mean Minimum Temperature by Months													
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Oahu—													
Ewa	60.9	60.4	61.6	63.3	64.7	66.5	67.9	68.6	67.9	66.5	64.5	62.8	64.6
Kahuku	63.9	63.4	64.8	66.8	68.3	70.2	71.0	71.9	71.6	70.2	68.1	66.2	68.0
Waialua	60.7	60.0	60.8	62.6	63.9	65.4	66.6	67.0	66.4	65.4	63.9	62.1	63.7
Waianae	62.4	62.0	63.6	65.3	66.7	68.0	69.8	70.2	70.0	68.6	66.4	64.2	66.5
Waimanalo	64.4	64.6	66.0	67.4	69.6	69.6	72.5	73.0	72.8	71.1	69.1	66.8	68.9
Waipahu	62.3	61.7	63.0	64.5	65.8	67.7	69.0	69.6	68.9	67.7	66.0	64.1	65.9
Maui—													
Hana	64.5	64.5	64.9	66.3	67.5	69.6	70.1	70.2	68.6	69.5	67.9	66.4	67.5
Kaanapali	62.2	66.5	63.0	64.4	66.6	68.2	68.5	69.0	68.8	67.5	65.7	63.7	65.8
Puunene	62.6	61.4	63.5	65.9	67.6	69.1	70.2	70.7	70.1	68.4	66.7	64.8	66.8
Wailuku	63.0	62.6	63.7	65.5	67.3	69.1	70.5	71.2	71.0	69.3	67.0	65.2	67.1
Kauai—													
Eleele	62.0	62.3	62.7	64.2	66.9	68.5	69.8	70.0	69.8	68.6	66.7	64.0	66.3
Kealia	62.5	62.1	63.7	65.9	67.9	70.2	71.4	72.0	71.5	70.0	67.4	65.1	67.5
Kilauea	61.7	61.5	62.5	64.4	65.7	68.0	69.0	69.9	69.2	68.0	65.9	63.8	65.8
Koloa	61.7	61.7	62.8	64.8	66.8	69.1	70.2	70.9	70.4	68.8	66.3	64.2	66.5
Lihue	60.6	60.1	62.0	64.0	66.1	68.4	69.5	70.1	69.6	67.5	65.0	63.1	65.5
Makaweli	62.3	62.4	63.1	64.4	66.4	68.4	69.6	70.0	69.7	68.4	66.4	64.3	66.3
Hawaii—													
Hakalau	63.0	62.6	63.2	64.5	66.2	66.9	68.0	68.6	68.0	67.6	66.1	64.6	65.8
Hilo	62.5	62.2	63.0	64.2	65.2	66.4	67.4	68.1	67.5	66.9	65.7	64.0	65.3
Honokaa	61.0	60.8	61.8	62.7	64.5	65.7	66.2	67.3	66.7	65.8	64.1	62.6	64.1
Kohala	62.2	62.3	63.0	63.9	65.4	67.1	68.1	68.7	68.9	67.4	65.7	64.3	65.6
Olau	60.2	59.9	60.9	62.2	63.1	64.3	65.3	65.9	65.6	64.8	63.3	62.2	63.1
Ookala	62.7	62.3	62.9	63.6	64.8	65.8	66.4	67.2	68.0	67.0	65.8	64.4	65.1
Pahala	58.8	58.5	59.2	60.4	61.3	62.1	63.1	63.5	63.8	63.2	62.0	60.8	61.4
Pepeekeo	63.2	63.1	63.5	64.8	65.8	66.5	67.8	68.4	68.4	67.4	66.3	64.7	65.8
Java (Paseroean)	73.8	73.8	73.6	72.7	72.0	70.5	68.7	69.1	70.5	72.5	73.8	73.8	72.1

TABLE E
TEMPERATURE DEPARTURES FROM THE AVERAGE
BY MONTHS
MEAN MAXIMUM TEMPERATURE

TABLE E
DEPARTURES FROM AVERAGE OF MEAN MAXIMUM TEMPERATURE

Station: Hakalau

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	-2.7	-2.2	-.6	-1.0	....	-.1	+.3	-.5	....	-1.3	-1.5	-1.0
1906....	+2.2	+3.3	+2.1	+3.7	+2.6	+2.8	+.8	....	....	....	....	....
1907....	+5.2	+3.4	+2.2	+1.8	+3.9	+2.9	+3.4	+1.0	+3.0	+2.1	+2.7	+2.6
1908....	+2.1	+.9	+1.8	+1.0	+.7	+.4	+.5	+2.1	+.8	-1.2	+1.6	-1.5
1909....	+1.5	0	-1.6	+.5	+.9	+1.5	+.4	+1.2	+1.3	+1.2	+2.3	+.9
1910....	-1.3	-.1	+.6	-.5	+.4	-.4	+1.1	+1.4	+2.6	+1.7	+1.6	+.9
1911....	0	-.1	+.5	-.6	-.5	-1.5	-1.1	+.3	-2.3	-1.4	-.8	+.2
1912....	+1.7	-.3	-2.7	-1.0	-.7	-1.4	-.5	+.9	+.5	-1.9	-1.1	+.1
1913....	-1.0	+.4	+2.1	+1.0	-.4	-.2	+.2	+1.0	-.4	-.3	-3.7	-5.8
1914....	-7.5	-4.0	-1.5	+1.6	-.5	+.5	+1.2	+2.2	+.3	+2.1	+2.1	-2.0
1915....	-1.4	-1.9	+.9	-.2	+2.4	+2.3	+.9	+1.7	+1.9	+.3	-2.0	+.3
1916....	+.6	+3.6	+2.5	+1.5	-.2	-1.2	-1.3	-1.8	-1.0	0	+.8	-.5
1917....	-.3	+.7	-.6	+1.0	0	+.4	+.6	+1.0	+1.7	+1.8	+2.0	+1.6
1918....	+1.4	-.7	-1.0	-1.5	-1.3	+.2	-.3	+.5	+.7	-.4	-1.0	-2.1
1919....	-2.3	-1.5	-3.0	+.6	-.7	-1.0	-.1	-1.4	+.6	-.7	-1.4	-.3
1920....	+1.3	+1.0	+.4	+.4	+1.7	-1.2	-1.1	-.6	-1.0	+.2	0	-.2
1921....	-1.6	+.4	+.2	+2.5	+5.0	+4.5	+3.3	+1.5	+1.0	+2.9	+3.5	+1.5
1922....	+1.9	-2.8	-2.5	-1.4	-2.8	-2.0	-1.1	-1.9	-2.4	-1.0	-2.0	+.6
1923....	-2.0	-2.2	-2.2	-1.7	-2.0	-2.5	-2.3	-1.2	-.5	-.4	-1.1	-1.5
1924....	-.9	-.2	-1.5	-.9	-2.0	-1.0	-2.2	-2.1	-1.2	+.3	-.9	+2.0
1925....	+.7	+1.1	+.4	-1.8	-2.7	-1.8	-1.1	-1.5	-1.4	+.1	+1.1	+3.9
1926....	+2.7	+1.7	+2.3	-1.1	+.7	+.9	0	-.6	+1.2	+.1	-1.2	+.8
1927....	+.7	+2.4	+1.8	+1.3	-.6	-.4	-1.0	-1.4	-1.1	-.8	+.7	+1.1
1928....	-.2	-3.2	+.3	-.1	-1.6	-.9	-1.8	-1.2	-2.7	-2.3	-1.3	-1.9
1929....	-1.8	-2.8	-1.4	-.9	-.9	-.5	+1.5	-.1	0	0	-.6	-.6
1930....	+.2	+2.1	-1.3	-2.9	-1.5	-1.5	-.2	-1.0	-1.1	-.3	....	....
Means ..	76.1	76.5	76.2	77.3	79.1	80.0	80.7	81.3	81.4	80.8	79.1	77.7

Station: Hilo

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	+.3	-.3	+2.4	+1.3	+.6	-2.6	-2.1	-1.5	-2.5	....	-.8	0
1906....	+1.9	+1.7	+.4	+1.8	+.3	+1.4	+.7	+.9	+1.2	+2.3	+1.6	+1.2
1907....	+2.5	+.6	-1.5	-.2	+1.9	+2.7	+1.7	-.5	+1.3	+.7	+1.5	+1.7
1908....	+.2	-1.5	+.8	-1.8	-1.7	-2.1	-2.1	-.9	-1.2	-1.6	+.3	-3.5
1909....	+.4	-1.7	-2.5	+.6	-1.4	-.1	+.2	-.4	-.6	-.1	+.4	+1.6
1910....	+.2	-.9	-.6	-2.3	-2.3	-2.4	-1.2	+1.7	+1.6	....	....	-.6
1911....	-2.3	-2.6	-1.1	-1.8	-2.0	-2.3	-1.5	-.9	+1.5	-1.9	-2.0	-1.7
1912....	+.6	+1.6	-4.2	-2.2	-2.3	-2.0	-1.5	+.4	-1.4	-1.2	-1.2	-.6
1913....	-1.3	-.3	-.1	-1.1	-1.1	-1.6	-1.9	-.2	-3.1	-4.5	-5.6	-1.2
1914....	-2.5	+.9	+.6	-.1	-2.5	-3.5	-4.2	-1.7	-1.7	+.2	+1.1	-3.0
1915....	-1.4	-3.6	+.6	-.2	+.6	+.2	-.3	+.6	+1.2	-1.7	-1.8	+.6
1916....	+.1	-4.9	-.1	+.9	+.8	-1.1	-.6	-1.5	+.5	0	+.2	-1.7
1917....	+.1	+1.5	-2.0	-3.2	+4.2	+2.0	+.6	+1.4	-.4	+2.9	+2.3	+4.6
1918....	+3.4	+2.3	+.3	+.8	-1.1	+.1	0	+2.1	+4.0	+2.4	+1.9	-.4
1919....	+.3	+.5	+.7	+2.0	+.5	+1.3	+.6	-.4	+.4	+.3	+1.2	+2.5
1920....	+2.8	+2.1	+1.0	+1.4	+4.7	+4.2	+3.0	+2.3	-.2	0	+.6	+.5
1921....	-1.4	+4.1	+2.5	+3.9	+1.8	+2.2	+.7	+.3	-.5	+.8	-.8	-.5
1922....	-1.5	-1.7	-1.1	+.3	-.5	+.8	+2.3	+.7	+.8	+1.2	+.1	+2.4
1923....	-1.2	+.1	-.2	+.5	+.9	-.1	+.1	+1.1	+1.2	+.8	-.2	-1.6
1924....	-.9	+.4	-.3	+.1	-.8	+.2	-1.2	+1.5	-.1	-1.2	+.2	+2.2
1925....	+.9	+2.4	-.4	-1.5	-1.5	+.1	+.5	-.7	-1.2	-.2	-.2	+2.0
1926....	+3.0	+2.1	+1.3	+.9	+1.0	+2.0	+1.3	+.2	+1.4	+.9	+2.2	+1.2
1927....	+.9	+3.0	+.3	+1.3	+.2	+.8	-.6	-2.1	-.5	-.6	+.1	-1.8
1928....	-1.1	-3.4	+2.2	+1.0	-.5	+.2	-1.2	-1.0	-1.6	-.8	-1.6	-2.4
1929....	-.8	-2.0	+.1	+.5	+1.3	+.3	-.1	+.3	+.8	-.5	-2.2	-3.1
1930....	-2.2	0	+.3	-2.2	+.1	+.4	+.9	+1.0	+1.6	+1.5	+2.0	+2.3
Means..	77.3	77.7	77.5	78.1	80.0	80.9	81.8	82.2	82.3	81.7	80.1	78.6

TABLE E

DEPARTURES FROM AVERAGE OF MEAN MAXIMUM TEMPERATURE

Station: Honokaa Mill

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	-3.8	-2.2	-2.6	-2.7	-1.9	-1.7	- .7	- .8	-1.2	-1.3	-1.4	-1.1
1906....	+1.2	+1.0	0	+1.3	- .5	+ .5	+1.0	+ .5	+1.1	+2.0	+2.2	-2.1
1907....	+1.2	-1.7	-5.1	- .9	+3.9	+1.4	+1.6	-1.0	- .8	-3.3	-2.3	- .9
1908....	-1.5	+ .1	+2.2	- .4	- .9	-2.3	-3.6	-3.1	-2.4	-2.7	-1.1	-2.8
1909....	- .5	-2.1	-2.8	- .2	- .6	- .2	- .9	+ .1	+1.0	- .1	+1.1	+1.3
1910....	-1.7	- .8	+ .4	- .6	- .7	-3.1	-2.1	-1.1	+1.0	-1.1	0	-2.0
1911....	-2.0	-1.9	+ .9	+1.3	+ .8	- .6	- .1	+ .6	-3.8	-2.6	-2.5	-3.0
1912....	- .5	-2.2	-3.8	-2.4	-1.7	-2.0	- .6	- .4	-1.0	- .5	- .6	- .5
1913....	+ .3	+ .5	+1.7	- .8	+ .2	+2.7	+4.0	+4.0	+2.8	+3.1	- .2	-1.2
1914....	-2.4	- .3	- .2	0	-2.7	- .9	+ .1	- .9	- .7	-1.3	- .9	-3.3
1915....	-1.5	-6.9	-2.0	-2.7	-4.5	+ .8	- .8	+ .4	- .5	-2.7	-2.8	- .6
1916....	- .6	+ .8	-2.0	-1.9	-2.9	-3.5	-2.6	-3.5	-2.7	-2.2	-2.6	-2.4
1917....	- .8	-1.0	-1.5	- .8	+ .4	- .9	+ .3	+ .9	+ .9	+ .4	- .3	- .1
1918....	+ .7	-2.5	-2.9	-4.7	-3.4	+ .1	-1.1	+ .3	- .8	-2.1	-1.4	-2.7
1919....	-2.0	-1.0	-2.8	-1.3	-1.7	-1.0	-1.6	-2.1	- .8	- .9	- .3	0
1920....	- .3	+3.0	+2.0	+3.6	+6.0	+3.9	+2.9	+1.0	+ .5	+2.2	+1.0	+ .6
1921....	+1.1	+3.6	+2.4	+2.0	+2.8	+2.7	+3.0	+2.4	+2.4	+2.0	+3.0	+5.1
1922....	+3.8	+2.6	+4.0	+6.3	+4.8	+1.9	- .5	- .2	+ .9	+3.3	+1.6	+3.5
1923....	+3.8	+3.4	+4.4	+5.6	+3.4	+2.7	+3.3	+2.7	+1.5	+2.7	+3.4	+1.4
1924....	- .7	- .6	- .4	0	- .1	+ .3	+ .1	+ .2	+1.4	-1.0	+1.0	+3.9
1925....	+ .9	+1.1	+1.9	+ .2	+ .7	- .5	+1.5	+ .2	+ .5	+1.8	+1.4	+6.2
1926....	+4.8	+1.9	+2.8	+ .1	+ .9	+2.2	+2.2	+1.1	+2.8	+3.7	+2.9	+3.5
1927....	+1.7	+4.3	+2.2	+1.7	+1.7	+1.9	+ .7	+ .7	+1.4	+2.1	+2.8	+1.5
1928....	0	+ .5	+3.3	+2.5	+ .7	-1.3	-3.9	- .9	-1.8	0	-1.6	-2.1
1929....	-1.4	-2.1	- .2	- .6	-1.1	- .6	+ .0	+ .5	+1.1	+ .7	0	-1.8
1930....	- .1	+1.6	-1.7	-4.2	-2.5	-3.4	-2.9	-2.8	-1.8	-1.7	-2.3	-2.8
Means..	77.2	77.9	78.2	78.6	80.4	82.0	82.3	82.7	83.1	82.3	80.2	78.0

Station: Kohala Mill

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	- .5	+ .6	- .1	- .8	- .9	+ .7	+ .4	- .2	- .9	-1.0	- .4	- .5
1906....	+ .7	+1.2	+ .7	+ .7	-1.2	- .7	- .8	-1.0	+ .5	+1.3	+2.1	- .3
1907....	+2.5	+ .4	-1.3	- .8	+2.5	+1.5	+ .4	-1.4	- .1	-1.1	- .7	+ .8
1908....	- .3	- .5	+1.9	- .8	-1.3	-2.4	-2.6	-2.0	-2.0	-2.7	- .8	-3.3
1909....	- .7	-1.8	-3.2	- .2	- .6	- .2	-1.8	0	+ .4	- .3	+ .6	+ .6
1910....	-2.2	-1.3	-1.4	-2.0	-1.4	-2.6	-1.8	-1.4	+1.5	-1.2	- .2	-1.3
1911....	-3.2	-2.9	-1.0	-1.0	-1.0	-3.2	-1.4	- .3	-2.4	-1.4	-2.6	-1.9
1912....	+ .7	- .7	-3.4	-2.5	-2.0	-2.2	-1.2	+ .7	- .1	-1.2	-1.9	-1.3
1913....	+ .2	- .3	+ .1	-1.1	-1.8	- .9	- .8	+ .6	+1.3	+4.6	+ .1	-1.0
1914....	-2.4	+1.6	+ .6	+ .4	-2.5	-3.0	-2.2	-2.6	-2.0	-2.3	-1.0	-1.1
1915....	-2.1	-4.5	+ .9	- .1	+1.2	+1.8	+ .8	+1.8	+1.3	-1.3	-1.8	- .2
1916....	- .5	+2.0	+ .3	+ .7	-1.2	-2.6	-2.2	-2.8	-2.3	-1.5	-1.5	-1.9
1917....	- .3	+1.6	- .7	+ .9	+ .7	+ .2	+1.4	+2.1	+2.2	+1.9	+ .5	+1.9
1918....	+ .5	-2.1	-2.6	-2.4	-1.8	- .2	-1.3	- .1	+ .3	0	+1.3	-1.1
1919....	+ .1	- .1	+ .7	+1.7	+1.5	+1.7	+1.0	+ .8	+1.2	+1.7	+2.7	+2.6
1920....	+2.8	+1.7	+1.1	+1.5	+3.4	+2.2	+2.4	+1.8	+ .2	+ .1	+ .8	+1.7
1921....	0	+2.0	+1.9	+ .8	+3.6	+4.9	+4.4	+4.9	+1.6	+ .6	-1.0	+2.2
1922....	+1.1	-2.1	-1.2	+ .9	+ .1	+1.8	+2.3	- .7	-1.6	-1.0	- .9	+ .8
1923....	-1.9	+ .1	- .2	- .2	- .4	-1.2	-1.2	+ .5	+ .5	0	-1.3	-1.3
1924....	+1.6	+ .9	+1.1	+2.1	+1.0	+ .2	- .5	-1.2	- .4	-1.6	0	+2.0
1925....	- .1	+ .9	- .1	-1.9	-1.5	-2.0	+ .5	- .6	+ .3	+1.0	0	+4.3
1926....	+2.5	+ .1	+ .9	-1.2	- .1	+2.1	+1.6	+ .6	+1.2	+2.4	+2.0	+2.5
1927....	+ .8	+3.3	-6.6	+1.1	+ .7	+1.1	- .4	- .9	+1.2	+ .6	+1.7	+ .7
1928....	- .2	0	+3.3	+3.4	- .1	- .1	- .7	+ .2	- .5	-1.1	-1.7	-4.5
1929....	- .8	-2.9	+ .7	+2.0	+3.5	+4.2	+3.2	+1.5	+3.1	+1.6	+2.6	- .1
1930....	+1.9	+2.9	+ .2	-1.8	- .6	-1.3	- .6	-1.2	-3.8	+ .9	+1.0	+ .8
Means..	77.2	77.3	77.4	77.7	79.5	80.7	81.2	81.7	82.1	81.8	79.8	78.0

TABLE E

DEPARTURES FROM AVERAGE OF MEAN MAXIMUM TEMPERATURE

Station: Olaa Mill

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	— .1	—2.2	+3.5	+3.0	+ .2	+5.1	+4.2	+6.3	+6.3	+5.6	+5.4	+8.8
1906....	0	+4.2	+5.8	— .1	— .3	+1.9	0	+1.0	— .3	+3.7	+4.1	+4.4
1907....	+6.5	+4.1	+2.2	+2.5	+3.1	+6.3	+4.3	+ .5	+3.8	+4.0	+4.1	+5.4
1908....	+ .9	—2.7	— .7	—1.9	—1.6	—2.2	2.4	—2.4	—2.7	—2.4	—1.5	—4.2
1909....	—2.6	—3.8	—2.9	+ .5	—2.1	— .8	—1.8	—2.1	—2.4	—1.7	— .8	—1.4
1910....	4.4	—5.2	—4.1	—4.6	—2.6	—3.8	—2.1	—2.9	—1.6	—3.1	—1.5	+ .6
1911....	+1.3	—4.3	—1.2	— .6	—1.4	—2.7	— .3	+1.0	+ .6	+1.1	+3.1	— .9
1912....	+3.1	+6.6	+3.4	+3.5	+ .8	+ .2	+ .5	+2.1	+1.1	+1.8	+ .1	+ .8
1913....	+ .7	+2.0	+1.8	+1.4	+3.0	+1.0	+1.1	+2.9	+1.7	+2.3	+ .1	+1.4
1914....	— .6	+ .1	+1.3	+1.1	—1.0	—2.3	—1.3	— .8	—1.4	— .6	+ .7	—1.1
1915....	0	—4.2	+1.2	+ .7	+3.0	+1.2	+1.2	+ .8	+ .7	—2.0	—2.4	— .4
1916....	+ .1	+ .9	+ .1	+1.1	— .7	—3.3	—2.5	—3.3	—2.3	—1.6	—1.7	—1.9
1917....	—1.4	+1.6	—1.6	— .3	+ .1	—1.1	+ .7	+ .1	+1.1	+ .6	— .3	+2.3
1918....	+1.5	—1.6	—4.0	— .9	+ .5	— .5	—1.5	— .9	—1.1	—1.0	— .3	—1.7
1919....	—2.2	—2.5	—2.3	+ .9	— .1	+ .3	+ .6	+ .4	0	— .4	— .7	+2.5
1920....	+2.7	+ .7	—1.1	+1.5	+4.0	+2.4	+2.1	+ .9	+ .3	—1.1	— .9	— .3
1921....	—2.0	+1.4	+3.3	+1.2	+2.5	+2.4	+3.3	+ .8	+ .2	+2.1	+ .3	— .3
1922....	0	— .4	+1.0	+ .8	+ .6	+1.1	+2.6	+1.9	+2.6	+3.7	+3.0	+4.3
1923....	+2.3	+3.8	—3.3	—7.0	—2.1	—7.1	—7.1	—4.6	—4.8	—6.4	—7.5	—7.4
1924....	—3.4	— .3	—1.9	+1.2	+ .9	+1.9	+ .1	+1.3	+ .8	+ .4	+2.3	+3.7
1925....	+1.9	+3.8	+1.2	— .1	+ .3	+2.1	+1.9	+1.1	+1.1	+1.2	+ .5	+4.8
1926....	+3.0	+2.4	+2.3	+1.5	+2.8	+4.3	+4.3	+1.5	+1.6	+2.5	+ .6	—1.2
1927....	—1.3	+1.6	— .9	+ .7	— .5	+ .7	— .7	—1.9	—1.0	—2.0	— .3	—3.8
1928....	—2.9	—3.4	+1.9	— .1	— .5	— .2	—1.6	— .1	— .9	—2.1	—1.5	—3.7
1929....	—2.6	—3.9	—3.6	—2.0	— .3	— .1	+ .3	+ .2	+ .8	— .7	— .4	—1.9
1930....	— .7	+1.0	—2.2	—4.4	+1.8	—5.6	—5.7	—4.5	—3.4	—3.9	—4.3	—7.7
Means..	79.8	81.1	80.9	80.4	81.5	82.7	83.2	83.4	83.7	83.4	81.6	80.4

Station: Ookala

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	—1.6	—1.9	—2.1	—2.5	—1.3	—2.1	—1.2	—2.0	—3.5	—2.4	....	—1.7
1906....	0	+ .9	—1.7	— .2	—2.6	+ .1	+ .3	—1.3	— .7	+ .4	+ .8	+ .1
1907....	+2.4	— .6	—2.5	—2.9	— .2	— .4	— .6	—1.0	+2.2	+ .6	+ .1	— .5
1908....	—1.8	—1.7	+1.2	—2.3	—2.6	—2.9	—2.5	—2.5	—1.9	—1.8	— .3	—3.8
1909....	+1.0	+1.1	—1.5	+1.9	+ .9	+ .4	—1.8	+ .4	+1.9	— .2	+ .2	— .5
1910....	....	—2.0	—1.2	— .5	—2.6	....	....	....	....	....	....	+6.8
1911....	+5.0	+3.5	+4.1	—1.5	—2.8	—3.8	—3.0	—1.4	—3.5	—3.6	—2.9	—3.3
1912....	—1.0	—1.4	—3.7	....	—1.0	—1.0	— .4	0	— .1	—1.6	—3.0	—2.8
1913....	—2.8	—1.6	—1.0	—1.2	—1.0	— .9	— .2	+ .7	+ .3	+ .4	—2.9	—2.4
1914....	—3.7	—1.3	—1.6	—1.4	—2.9	—3.1	—2.7	—2.3	—2.6	—2.5	—2.1	—2.7
1915....	—2.9	—4.9	—1.5	—1.9	+ .1	0	— .6	+1.2	+ .9	—2.0	—1.9	— .4
1916....	+1.0	+1.5	+ .6	+ .1	— .7	—2.5	—2.7	—2.9	—2.0	— .5	+ .1	+3.5
1917....	+3.3	+2.1	+ .2	+ .7	+ .7	0	+1.1	+2.8	+3.3	+2.3	+ .5	+2.3
1918....	+2.2	+ .3	—1.5	—1.7	—1.6	— .2	— .8	— .4	+ .9	+ .5	— .6	—2.0
1919....	— .2	—1.3	—1.0	0	— .3	+1.0	+1.6	+1.1	—4.1	—2.5	— .7	+1.0
1920....	—1.7	—1.8	+1.7	+2.0	+3.1	+3.2	+3.2	+2.1	+ .9	— .8	— .1	—1.2
1921....	—2.9	+1.1	+1.1	+ .1	+ .7	+1.3	+ .4	—1.3	—1.7	— .6	+1.1	+1.5
1922....	+1.8	— .5	+2.0	+3.5	+2.5	+ .6	+ .9	+1.1	+1.1	+1.2	+1.6	+2.2
1923....	—1.3	+1.6	+2.0	+ .7	—1.0	—2.1	—2.7	—1.3	— .4	+ .9	+1.1	— .8
1924....	—1.0	— .9	—1.3	+ .9	+1.8	+1.9	+1.7	— .3	+ .9	— .2	+1.7	+3.6
1925....	+2.1	+2.9	+2.0	+ .7	+ .2	+ .5	+ .9	+ .8	+ .3	+1.2	0	+1.8
1926....	—2.9	+1.7	+2.4	+ .2	+1.6	+3.6	+3.5	+2.4	+3.0	+2.1	+1.0	+2.0
1927....	— .1	+3.8	+1.7	+ .6	+2.9	+1.5	+1.1	+ .2	+1.5	+2.1	+1.7	— .3
1928....	+2.3	+2.1	+3.7	+5.0	+4.5	+3.4	+ .5	+ .8	— .1	— .5	— .4	—1.9
1929....	—1.6	—4.9	—1.0	+ .5	+1.0	+1.9	+2.5	+3.3	+4.3	+3.5	+2.5	—2.2
1930....	—1.8	+1.0	— .6	—2.0	0	— .9	+ .3	....	....	+3.2	+2.7	+2.1
Means..	77.3	77.4	77.7	77.9	79.5	81.2	81.6	82.1	82.2	82.0	80.3	78.6

TABLE E

DEPARTURES FROM AVERAGE OF MEAN MAXIMUM TEMPERATURE

Station: Pahala

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	— .4	+1.9	+2.0	+2.5	+3.1	+1.5	+2.0	+2.6	+2.2	+2.5	— .5	+ .1
1906....	+ .9	+ .7	+1.8	+2.4	+1.6	+1.3	+2.8	+ .1	+ .6	+2.7	+1.1	0
1907....	— .3	+ .1	—1.4	— .7	0	+ .9	+ .3	— .7	— .6	— .4	+1.0	+1.8
1908....	+1.4	— .8	—1.6	—1.4	—1.5	— .4	+ .2	+1.1	+ .7	— .5	+1.6	+2.2
1909....	+2.6	+1.0	—1.0	—1.8	—1.7	— .1	— .2	— .3	— .4	— .2	+ .1	— .3
1910....	— .6	— .1	— .3	— .7	0	+ .5	— .6	— .5	—1.9	— .5	+ .2	+ .6
1911....	— .5	—1.1	—1.2	— .8	+1.2	+ .2	+ .7	+1.9	+1.4	+ .5	+1.7	+3.6
1912....	+2.1	+3.0	— .4	+2.7	+1.8	+1.7	+1.2	+3.0	+3.8	+3.9	+4.5	+3.8
1913....	+1.0	+1.9	+2.2	+2.7	+ .8	— .7	0	+ .5	+ .8	+ .4	— .8	+ .3
1914....	+2.3	—1.2	—1.1	— .6	—1.5	— .8	—2.0	—1.9	—2.5	—1.1	—1.0	—1.7
1915....	— .7	—1.8	— .6	— .4	0	—1.1	—1.9	—1.6	— .3	—1.4	—2.4	—1.3
1916....	— .8	+1.0	—1.1	+ .8	+1.1	+1.2	— .8	—1.0	+ .8	— .6	—1.6	—1.9
1917....	—2.2	— .6	—1.4	—1.9	—2.7	—2.5	—2.2	—1.5	0	— .8	+1.3	— .5
1918....	+1.5	— .9	—1.0	—1.6	—1.1	—1.3	—1.2	—1.4	—1.8	— .8	— .1	+ .3
1919....	— .7	— .6	—1.3	—1.5	—1.0	—1.8	—1.2	— .2	—1.8	—2.0	—2.0	+ .4
1920....	+1.1	— .5	— .4	—1.9	—1.5	—2.0	—3.1	—3.1	—4.4	— .9	—2.9	—1.7
1921....	—4.7	—2.4	— .9	—2.8	—1.7	— .5	— .6	—1.1	—1.1	—1.1	— .8	—1.9
1922....	—1.5	—3.6	—1.0	—1.2	—2.4	—1.9	—1.8	—1.1	— .5	— .7	— .8	— .7
1923....	—2.6	—1.0	—1.2	—1.1	— .9	— .8	— .3	+ .4	— .3	+ .6	— .1	— .6
1924....	— .6	+ .3	0	— .9	— .9	— .6	—2.3	—3.1	....	— .8	+ .2	+ .3
1925....	+ .9	+1.8	+2.3	+1.6	+ .5	+3.3	+2.2	+3.3	+3.4	+2.9	+ .4	+1.9
1926....	+2.5	+2.4	+3.2	+2.6	+3.4	+3.3	+3.8	+2.7	+2.4	+2.4	+ .7	+1.1
1927....	+ .8	+3.7	+1.5	+2.6	+1.7	+2.2	+2.8	+1.7	+1.4	— .8	+ .4	—3.0
1928....	— .2	— .3	+1.8	+2.0	+2.1	+2.1	+ .8	+1.2	— .3	—1.2	— .8	— .7
1929....	+ .3	—2.2	— .2	— .6	+ .7	0	—1.1	+ .6	— .9	—1.7	—2.3	—1.7
1930....	—1.2	— .5	+ .1	—1.0	+ .1	—3.3	+1.8	—1.0	—1.9	+ .4	+2.2	+ .4
Means..	78.2	78.6	78.6	79.7	80.7	81.9	83.7	84.0	84.0	83.0	81.4	79.8

Station: Pepeekeo

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	—2.1	—1.6	— .9	— .4	— .7	— .2	+ .8	+ .4	+1.3	— .4	— .8	+ .2
1906....	+1.3	+1.5	— .1	+1.1	+ .2	+1.1	+1.2	+ .7	+1.8	+1.8	+ .8	— .1
1907....	+1.3	+1.3	—1.5	—1.1	+ .9	....	+1.9	0	+ .2	+ .2	+ .3	+ .3
1908....	+ .2	—1.7	— .1	— .8	+3.6	— .5	— .5	+ .7	+ .3	+ .5	+3.4	+1.6
1909....	+2.6	+ .8	+ .7	— .1	—1.2	— .3	—1.3	— .9	—1.0	— .7	0	+ .2
1910....	—2.0	— .6	— .1	—1.4	—1.2	—1.4	—1.0	— .7	+1.4	— .2	— .7	— .5
1911....	— .7	—2.8	+ .6	— .3	— .1	— .9	— .7	+ .4	— .6	+ .2	— .9	—1.0
1912....	+1.6	+ .7	—1.5	— .3	— .3	— .2	+ .1	+ .5	+1.4	+ .6	+1.0	— .6
1913....	+ .2	+2.3	+2.6	+1.5	+1.1	+1.8	+1.6	+1.3	+1.5	+1.7	— .8	+ .7
1914....	— .1	+ .2	+ .3	+ .4	—1.9	—2.5	—1.3	—1.5	—1.4	+ .2	+1.2	+ .3
1915....	+ .5	—2.5	+ .9	+ .8	+1.6	+1.8	+ .8	+1.3	+2.3	+ .2	—1.7	+ .8
1916....	+1.5	+2.8	+2.2	+1.2	+1.0	+1.1	....	+ .6	....	+1.3	0	— .1
1917....	0	+ .6	+ .3	+ .8	+ .3	0	+1.1	+1.4	—1.0	—3.7	—4.2	—4.4
1918....	—4.6	—6.4	—6.7	—5.5	—5.1	—1.4	—2.2	—2.2	—2.4	—2.0	—3.8	—4.3
1919....	—4.9	—2.9	3.7	—2.6	—3.6	—2.9	—3.2	—4.6	—3.4	—4.5	—4.4	—3.6
1920....	—3.7	—3.2	—1.8	—2.3	— .9	—5.1	—5.1	—3.5	—2.4	—4.0	—4.6	—4.6
1921....	—4.8	+ .5	— .6	— .9	—1.3	— .5	—1.5	—3.3	—3.2	—2.7	+ .1	+ .5
1922....	+ .9	— .3	— .7	+ .5	— .9	— .2	+ .8	+ .8	+1.3	+1.1	— .4	+2.8
1923....	0	+ .6	— .6	— .1	+ .3	+ .1	+ .3	+1.1	+2.0	+1.9	+1.3	— .7
1924....	+1.6	+ .9	+ .8	+1.3	+ .9	+1.8	+ .8	+1.1	+2.3	+ .6	+2.5	+4.2
1925....	+3.6	+2.5	+1.1	+ .4	+ .8	+ .7	+ .5	+ .7	+1.8	+1.4	+1.7	+3.1
1926....	+4.3	+1.8	+4.3	+2.7	+2.2	+2.5	+1.8	+ .8	+ .5	0	+ .7	+ .1
1927....	— .2	+2.8	+ .2	+1.3	+ .4	+1.3	+ .2	—2.0	+ .2	— .4	+ .2	—1.4
1928....	+ .4	0	+2.5	+1.9	+1.0	+1.2	+ .8	+1.7	+1.7	+ .4	+ .8	+ .1
1929....	+1.1	+ .2	+ .8	+2.0	+2.3	+2.7	+2.3	+3.1	+4.4	+2.7	+3.6	+2.9
1930....	+3.2	+4.4	+1.4	0	+ .4	+ .9	+1.4	+1.1	+2.1	+3.0	+3.5	+3.5
Means..	77.5	78.0	77.6	77.9	79.4	80.2	81.3	81.9	81.8	82.0	80.6	78.9

TABLE E

DEPARTURES FROM AVERAGE OF MEAN MAXIMUM TEMPERATURE

Station. Eleele												
Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1917....	+4.8	+5.4	+5.6	+2.5	+2.2	+ .9	+1.7	+4.7	....	+1.0	— .7	—1.6
1918....	0	2.7	—3.3	—3.2	— .8	— .9	....	— .9	0	— .1	—2.0	—2.4
1919....	+ .2	— .8	—1.1	+1.4	—2.2	—2.6	—4.0	—2.0	— .6	+1.3	+1.1	— .2
1920....	+ .7	+ .3	— .6	+ .1	+1.6	—1.5	—2.0	—2.7	3.5	—3.0	—2.1	—2.2
1921....	—5.0	+ .2	—1.6	—3.0	+1.0	—1.0	—2.0	—3.5	—3.5	—1.3	—2.2	—3.2
1922....	—2.0	—3.4	—2.0	— .7	—3.1	— .8	0	+ .1	+1.4	+ .7	— .4	+3.2
1923....	—1.6	— .9	—2.1	—2.0	+ .1	—1.0	—1.5	+ .1	+1.8	+1.2	+ .1	—2.9
1924....	—1.4	—2.6	—2.1	—1.9	—2.4	— .4	—3.7	....	—3.2	—3.0	—1.9	—2.4
1925....	+ .5	+1.6	+ .2	+ .1	— .5	+ .7	+1.8	—1.0	— .1	+ .4	— .3	+2.7
1926....	+1.7	+ .5	+1.5	+ .2	+ .9	+ .9	+1.9	+ .3	+ .4	+ .3	+4.8	+5.1
1927....	....	....	+1.5	+ .7	— .8	+ .7	+ .1	— .3	+ .9	+ .4	+1.4	+ .6
1928....	+ .7	— .3	+2.1	+2.3	+ .6	+1.5	+ .6	+ .7	+ .7	— .3	—1.5	+ .4
1929....	+ .9	+ .4	+1.6	+2.3	+1.7	+2.9	+3.2	+2.9	+3.9	+2.8	+1.5	+1.1
1930....	+1.0	+2.6	+ .6	+1.3	+2.0	+1.2	+3.3	+1.1	+1.7	+ .7	+1.6	+2.8
Means..	77.8	79.0	79.1	79.6	81.7	82.6	82.9	84.4	84.0	83.5	81.0	78.8
Station: Kealia												
1905....	—4.4	—2.1	—2.8	—3.2	—2.8	—2.6	—2.9	—3.0	—2.6	—2.4	—2.4	—3.4
1906....	—1.2	—1.0	—2.6	—1.8	—2.1	—1.5	—2.2	—2.4	—2.5	—1.6	—1.3	—1.8
1907....	—1.1	....	—8.0	....	....	....	....	....	....	—2.1	—2.8	—1.5
1908....	....	....	—2.1	—2.5	—3.4	—3.5	—3.8	—3.8	—4.4	—4.4	—2.8	—2.2
1909....	—2.1	—3.4	—3.5	—2.2	—3.6	—3.4	—4.1	—4.3	—4.0	—3.7	—2.3	—1.2
1910....	—3.2	—3.6	—1.8	—2.8	—3.7	—3.9	—3.1	—3.4	—1.7	—2.5	—2.4	—2.9
1911....	—3.4	....	+ .1	—1.5	—1.5	—2.4	—2.9	—2.3	—4.5	—3.4	—2.4	—1.8
1912....	— .5	—1.1	—3.0	— .8	—2.2	—1.6	—2.1	—1.9	—1.6	—1.3	....	+ .2
1913....	+1.2	— .4	+ .1	—1.0	— .6	+1.3	— .6	+ .3	+ .3	+1.2	+ .9	— .1
1914....	— .7	....	— .2	— .2	—1.3	+ .5	+ .7	— .2	— .6	+1.1	+ .9	0
1915....	+ .8	— .9	+3.1	+1.4	+ .9	+1.7	+1.0	+1.0	+1.2	— .2	— .7	+ .4
1916....	+1.6	+3.7	+3.7	+4.8	+1.0	— .2	— .3	— .7	— .4	+1.2	+ .8	+ .8
1917....	+ .6	— .9	—1.4	+ .4	+ .7	0	+ .1	+ .9	+1.3	+ .9	+1.5	+2.0
1918....	+2.2	+ .4	— .9	—2.9	+ .3	+ .5	0	+ .2	+ .8	+ .9	+ .8	— .7
1919....	— .3	—4.2	+1.0	+1.2	+ .2	+1.7	+1.3	+1.3	+ .7	+1.7	+1.9	+1.9
1920....	+ .8	+2.0	....	+ .5	+2.8	+1.1	+ .7	+1.4	+1.0	+1.4	+ .8	+ .8
1921....	—1.5	+1.8	+ .8	+1.4	+ .7	+1.2	+ .7	— .1	— .3	—1.1	+ .6	—1.2
1922....	+ .4	— .4	+ .7	+1.0	+ .7	+ .3	+1.2	+1.2	+ .1	+ .2	— .4	+1.3
1923....	—1.4	—2.4	— .7	— .1	— .2	— .1	0	+ .1	+ .6	+1.0	+ .2	— .7
1924....	+ .3	+ .6	+ .8	— .9	+ .3	+ .8	+ .6	+1.0	+ .9	— .1	+ .5	+1.3
1925....	+2.5	+2.5	+2.9	+1.4	+1.4	+1.1	+ .9	+1.5	+1.5	+1.8	+1.5	+1.1
1926....	+2.8	+2.6	+4.7	+2.2	+3.6	+2.5	+3.9	+2.3	+2.7	+3.6	+2.6	+3.0
1927....	+2.4	+3.4	+3.3	+2.5	+2.7	+3.9	+2.4	+2.7	+2.6	+2.3	+2.4	+ .4
1928....	+2.4	+1.5	+3.9	+3.0	+2.1	+2.1	+3.9	+2.2	+2.2	+1.3	—1.0	+1.2
1929....	+1.8	+2.2	+2.5	+2.3	+3.0	+2.8	+2.7	+3.7	+4.7	+2.2	+ .3	—1.0
1930....	+1.2	+2.5	+ .7	+ .2	+1.9	+1.1	+1.8	+2.1	+1.5	+2.4	+3.2	+2.9
Means..	78.2	78.8	78.7	79.8	81.6	83.1	84.3	85.0	85.3	84.1	81.8	79.8

TABLE E
DEPARTURES FROM AVERAGE OF MEAN MAXIMUM TEMPERATURE

Station: Kilauea												
Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	-2.8	-1.5	-1.2	-2.0	-2.3	-1.7	-1.9	-1.8	-.9	-1.3	-1.1	-1.5
1906....	-.8	0	-2.0	+1.1	+.5	+1.3	+.5	+.1	+.3	+.4	+.7	-.9
1907....	-.3	+.1	-2.3	-.9	+.4	-.2	-.7	-1.3	+.1	-.2	-.5	+.1
1908....	+.1	-.1	+.3	-.4	-1.0	-1.4	-.7	+1.5	-1.8	-2.3	+.3	-.5
1909....	+1.1	-1.8	-2.7	0	-.4	-.3	-.9	-1.2	-.3	-1.3	+.9	+.1
1910....	-.3	-1.6	+.8	+.4	-.5	-2.3	-.9	-1.0	+.6	-.6	+.2	-.5
1911....	-3.2	-2.4	-.1	+.5	-.8	-1.5	-1.1	-.3	-2.4	-.9	-.2	-.7
1912....	+1.5	-.1	-2.1	-.6	-.6	-.3	-.9	-.8	+.1	0	+.1	+.6
1913....	-.2	-2.0	+.4	+.3	+.2	0	+.2	+1.2	+.8	+.7	-.3	-1.1
1914....	-3.9	+.3	-.9	-.7	-2.8	-1.9	-1.9	-.8	-2.4	-1.9	-.9	-2.1
1915....	-.9	-2.8	+1.7	-.3	+1.1	+1.3	+1.4	+2.5	+1.6	-.4	-1.4	-1.0
1916....	+.3	+1.2	+1.4	+2.4	-.4	-1.3	-.9	-1.7	-.6	-1.1	-1.1	-1.3
1917....	-1.7	-1.3	-.8	+1.1	+1.1	-1.5	-.5	0	+.6	+.9	+.9	+1.8
1918....	+.3	-.6	-2.7	-2.9	-1.6	-1.6	-1.5	-1.1	+.1	+.1	-.6	-1.2
1919....	-1.3	-2.7	-.4	+.8	-.5	+.3	-.6	-.5	+.3	+1.1	+1.9	+.9
1920....	+.9	+.6	-.2	-.4	+1.5	+.2	-.1	0	-.9	-.4	-.8	+.2
1921....	-2.1	+2.1	+1.7	+1.2	+1.2	+1.8	+2.5	+.7	-.2	0	-.7	-.3
1922....	-.4	-2.1	+.2	+.5	-1.3	+.7	+1.3	+.2	-1.1	+.1	+.5	+3.0
1923....	-.7	-1.9	-1.2	-.4	+.4	+.5	+.3	+1.6	+.8	+.5	+.8	+1.6
1924....	+1.5	+.8	+1.0	-1.4	-.8	+.5	-.2	+.6	+1.3	-.5	+.6	+1.5
1925....	+1.5	+2.2	-.9	....	+2.3	+1.0	+3.0	+1.8	+2.3	+2.5	+3.2	+4.5
1926....	+4.9	+3.3	+1.9	-5.1	-2.2	-2.8	-1.0	-1.4	-2.0	-2.7	-4.7	....
1927....	+6.2	+2.4	-2.2	-.5	-2.0	+3.4	+.5	+.4	-.6	-.2	-1.6	-4.3
1928....	-2.7	+3.9	+6.0	+3.2	+2.2	+1.6	+.9	+1.3	+1.0	+2.2	+.7	+2.0
1929....	+1.2	+1.3	+2.6	+3.8	+3.3	+2.5	+2.1	+3.3	+3.2	+2.1	+1.1	-.1
1930....	+1.2	+1.6	+1.0	-.6	+2.2	+1.9	+1.5	-.5	+.9	+3.5	+2.3	....
Means..	76.4	77.4	76.8	77.8	79.9	81.5	82.4	82.9	83.0	81.7	79.1	77.3

Station: Koloa												
1905....	+.3	+1.4	+2.1	+.3	-.1	+.7	+1.6	+.3	+.2	+.6	+1.9	+1.2
1906....	+1.9	+1.5	-.8	+1.6	+.9	+2.3	+1.9	+1.0	+1.0	+1.8	+1.9	+.6
1907....	+2.0	+1.2	-1.5	-.8	+1.4	+.6	+.3	-1.4	+1.3	+.5	+1.4	+2.3
1908....	+2.2	+1.6	+1.5	-.2	-.6	-.6	-.1	+.1	-.6	-.6	+1.4	+.9
1909....	+1.0	-1.0	-2.6	-.1	-.8	-.5	-1.6	-.5	-.7	-.8	+1.7	+.9
1910....	-.5	+.2	+.6	-1.5	-1.3	1.8	+.2	-.4	+.7	+.4	+1.4	+1.4
1911....	-.2	-.5	+1.4	+1.4	0	-.4	0	+1.4	-1.2	+1.2	+2.6	+2.7
1912....	+3.8	+1.2	-1.0	+1.2	+2.3	+2.3	+1.0	+1.3	+.6	+1.1	+.6	+2.2
1913....	+2.6	-.1	+1.5	-.2	+.9	-.1	+.7	+2.1	+1.9	+2.5	+.1	+1.4
1914....	1.6	+2.2	+.7	+.4	-1.3	-1.2	-.5	-1.0	-2.1	-.4	+.6	+.3
1915....	+1.0	-2.5	+1.4	0	+2.2	+.8	+1.4	+.5	0	-1.2	-1.0	+.2
1916....	-.5	+.9	+.4	+1.6	-1.2	-2.1	-1.0	-1.6	-1.0	-.8	-.7	-3.7
1917....	+.4	-.3	-1.2	-.5	-.8	-1.8	-1.6	-1.0	-.3	-.7	-.6	-.5
1918....	-.5	-2.4	-4.0	-4.4	-2.4	-1.5	-2.8	-2.2	-1.2	-1.6	-1.4	-2.3
1919....	-1.8	-1.5	-1.4	-.7	-1.9	+1.2	+.2	+.5	+.6	+.7	+.5	+.4
1920....	+1.0	+1.3	+.4	+.2	+1.9	+.2	+.1	+.6	-.8	-.6	-1.4	0
1921....	-2.0	+1.9	+1.1	+1.0	+2.0	+1.8	+.1	-.4	-1.0	-.2	-1.1	-1.8
1922....	-1.5	-3.0	-.9	+.5	-1.4	-.3	+.5	+.1	-1.1	-.1	-.3	+1.7
1923....	-1.5	-1.2	-.6	+1.1	+.3	+.7	0	+1.0	+1.5	+.5	+.5	-1.9
1924....	-.2	+.1	+.4	+.2	-.5	+.1	-1.0	-1.2	+.1	-1.4	-.2	-1.6
1925....	-2.6	+1.1	+.3	-1.8	-1.4	-1.1	-.2	-.5	-.2	+.6	-.4	+.1
1926....	+.8	+.3	+1.6	+1.2	+2.8	+1.3	+1.6	+1.3	+.5	+1.7	+1.2	+1.5
1927....	+.4	+1.2	+.5	+.1	-.8	+.8	-.4	+.2	+.7	+.4	-.8	-1.3
1928....	-.5	-1.7	+2.0	+.1	-.3	-.5	-1.6	-.5	-1.6	-1.7	-2.2	....
1929....	1.5	-1.2	-.2	+.4	+.3	+.3	+1.1	+.8	+1.5	-.6	-1.8	-3.2
1930....	-2.0	+.1	-1.3	-2.6	-.1	-.7	+.4	-.3	+.2	-.4	-3.5	-.4
Means..	76.2	77.4	77.5	78.3	80.0	81.2	81.9	82.7	83.2	82.2	79.5	77.3

TABLE E

DEPARTURES FROM AVERAGE OF MEAN MAXIMUM TEMPERATURE

Station: Lihue

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	— .9	— .1	+1.0	— .9	— .7	0	— .5	— .7	— .9	—1.3	+ .1	— .5
1906....	+ .7	+1.6	— .8	+1.5	+1.2	+1.8	+1.7	+1.0	+1.6	+3.2	+2.8	+1.4
1907....	+1.9	+3.3	+ .4	+1.7	+2.6	+1.8	+1.4	—1.6	+ .3	+ .6	+ .4	+ .2
1908....	+ .8	+ .4	— .1	+ .2	— .3	— .6	— .8	— .9	—1.8	—1.9	— .2	— .4
1909....	— .3	—1.1	—2.4	—1.0	— .7	+ .1	— .3	— .1	—1.1	—1.0	0	—1.4
1910....	—2.0	—1.5	— .3	—1.3	—1.6	—3.2	—1.2	—2.1	+ .3	— .9	0	—1.0
1911....	—2.3	—2.7	— .3	+ .1	—1.1	— .8	+ .5	— .2	—1.7	—1.0	+ .3	— .4
1912....	+1.3	0	—2.4	+ .2	+ .6	+1.2	+1.1	+1.0	+1.1	+ .9	+ .1	+1.4
1913....	+1.5	— .8	— .1	— .9	—1.1	—1.1	— .6	+ .4	— .1	+1.0	—1.1	— .4
1914....	—2.7	+ .2	— .6	— .4	—3.0	—1.8	—2.0	— .8	—2.2	—1.0	— .5	—1.0
1915....	—1.3	—3.2	+1.0	— .5	+1.0	+ .1	+ .2	+ .6	+ .8	—1.9	— .5	+ .4
1916....	— .5	+ .1	+ .9	—1.4	—1.6	—1.7	—2.5	—1.8	—2.2	—1.5	—2.1	— .5
1917....	—1.3	—2.5	—2.8	—1.0	—1.0	—1.6	—1.7	—1.7	—1.3	— .9	+ .4	+ .1
1918....	— .3	—1.4	—3.1	—3.6	—2.1	—1.0	+ .3	— .3	— .3	— .1	— .1	—1.4
1919....	—1.4	— .7	— .1	+ .2	— .9	— .1	— .5	+ .4	0	+1.3	+1.0	— .5
1920....	+ .2	+ .7	+ .5	+ .4	+1.5	— .2	+ .2	— .7	— .4	+ .4	+ .9	— .8
1921....	+2.0	+2.7	+1.3	+1.1	+1.6	+1.4	+1.6	+ .7	+ .1	— .1	+ .3	— .8
1922....	— .1	—1.6	— .6	+1.0	+ .1	+ .5	+1.4	+1.3	— .4	— .3	— .9	+1.4
1923....	—2.1	— .9	— .8	0	+ .4	+1.1	+1.8	+1.1	+1.2	—1.0	—5.8	—3.5
1924....	0	+ .3	+ .5	+ .2	+ .5	+ .9	+ .1	+ .4	+2.3	0	+ .1	+1.2
1925....	+1.6	+2.2	+1.5	— .3	+ .6	+ .2	— .3	+ .8	— .2	+1.5	+ .4	+1.9
1926....	+2.1	+1.9	+2.5	+1.8	+2.5	+1.2	+1.4	+1.6	+2.0	+3.6	+2.5	+3.1
1927....	+1.1	+2.3	+1.4	+ .7	— .5	+ .3	— .4	+ .5	+1.0	+1.2	+ .4	— .8
1928....	+ .6	+ .3	+2.7	+ .7	— .1	+1.4	—1.0	+ .2	+ .2	+ .8	—1.1	— .6
1929....	— .5	— .4	+ .4	+ .8	+1.1	— .1	+ .1	+ .5	+1.8	+ .9	+ .3	—1.2
1930....	+ .7	+1.8	+ .8	— .7	+1.1	+ .3	+ .2	— .2	+ .3	+1.4	+1.8	+1.7
Means..	76.9	77.3	77.5	78.3	80.4	82.2	83.3	83.9	84.0	82.6	79.8	78.1

Station: Makaweli

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	+ .1	+2.2	+1.1	+1.9	+1.4	+1.1	+1.3	+1.6	+1.9	+1.6	+2.7	+1.3
1906....	+ .9	+2.0	0	+3.2	+2.2	+3.8	+2.0	+1.5	+1.6	+1.4	+1.2	—1.3
1907....	—1.2	—1.2	— .7	—2.3	—1.4	— .6	— .6	— .9	+ .2	+ .3	+ .8	+1.9
1908....	+ .9	+1.2	— .3	— .9	+ .5	— .5	— .7	— .4	— .1	— .1	+ .8	+1.0
1909....	+ .4	—1.1	— .7	—2.0	— .9	— .7	—1.3	—1.8	—1.6	— .4	+ .6	— .6
1910....	— .6	— .4	+1.1	— .7	—1.7	—1.7	—1.5	—1.6	—1.0	—1.0	— .7	— .5
1911....	—1.9	—1.7	— .9	— .8	—1.8	—2.3	—3.3	—1.5	—2.6	—1.8	— .7	+ .3
1912....	+2.5	+1.8	— .4	+ .6	+ .3	— .5	— .4	+ .2	— .3	+ .8	+1.1	+1.4
1913....	+2.8	+1.0	+2.3	— .3	— .3	—2.1	— .4	+1.5	+1.8	+1.6	— .1	+3.2
1914....	0	+2.8	+1.9	+ .5	— .7	+ .1	0	+ .4	— .6	+ .1	+1.0	+ .8
1915....	+ .9	— .3	+1.4	+ .8	+ .9	+1.1	+ .7	+ .1	+ .3	— .9	—1.3	+4.7
1916....	— .5	+ .3	0	+ .2	— .9	—2.2	—1.3	—1.0	—1.5	+ .2	— .1	—1.0
1917....	+ .1	+ .9	— .8	— .6	— .9	— .5	—1.2	—1.2	+ .4	+ .1	+2.5	+2.8
1918....	+3.3	+ .2	— .7	—1.7	—1.2	— .4	— .7	+ .6	+ .2	+1.5	+1.5	+ .6
1919....	+2.8	+1.6	+2.4	+3.1	+1.2	— .2	— .6	0	— .5	— .6	0	— .5
1920....	+ .3	0	0	—1.1	— .8	— .6	+ .1	+ .2	— .5	—2.1	—6.9	—6.7
1921....	—7.3	—5.3	—4.5	—2.8	+ .5	+1.4	+ .4	—1.0	— .2	+ .5	— .2	—2.2
1922....	— .1	—1.3	— .4	+1.0	— .6	+ .7	+2.6	+ .5	0	+ .7	+ .3	— .6
1923....	— .8	—2.0	—1.1	— .5	— .7	— .6	+ .4	— .3	+1.0	+ .5	+ .4	—1.6
1924....	— .5	0	+ .7	— .2	0	+ .8	+ .1	— .1	+ .6	—1.5	—1.0	— .7
1925....	+ .1	+ .7	+ .5	—1.1	— .2	— .4	— .4	— .3	+ .1	0	— .4	—1.0
1926....	— .1	— .8	+1.2	+ .5	+1.7	+ .3	+1.1	+ .8	+ .3	+1.1	+1.1	+ .6
1927....	— .2	+ .4	+ .1	+ .5	+ .4	+1.6	+ .2	+ .7	— .2	0	— .2	— .8
1928....	— .4	—1.5	+ .9	+1.8	— .3	+1.0	— .2	+ .2	0	— .8	—2.4	— .9
1929....	— .3	— .7	+1.0	+1.1	+ .9	+1.4	+ .8	+ .8	+1.5	+1.1	— .8	—1.0
1930....	— .5	+1.3	— .4	— .8	+2.1	+1.2	+1.8	+ .1	—1.4	+ .3	+ .1	....
Means..	78.7	79.8	80.0	81.4	83.4	85.1	86.4	87.2	86.7	85.4	82.7	80.7

TABLE E

DEPARTURES FROM AVERAGE OF MEAN MAXIMUM TEMPERATURE

Station: Hana

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907....	....	....	....	....	+5.2	+3.8	+ .6	-1.0	+ .6	-1.2	-.7	+1.2
1908....	+4.3	+4.8	+3.9	+3.7	+ .7	-.3	+ .5	-.6	-4.2	-4.3	-3.8	-5.9
1909....	-3.5	-6.0	-5.3	-2.1	+ .4	-.6	-1.9	-.1	+ .2	-.3	+ .4	-1.1
1910....	-4.2	-2.0	-1.0	-.1	-1.1	-.8	-.2	-1.3	-.2	-.3	-.1	-3.4
1911....	-3.2	-3.9	+ .8	-.6	-.4	+ .6	+1.2	+ .2	-2.7	+1.4	+ .1	-.6
1912....	+ .8	-1.5	-3.7	-.3	-.1	-1.9	-1.6	+ .6	+ .8	-.2	-.3	+1.0
1913....	+1.4	-1.6	-.3	-.4	-1.9	0	+ .7	+ .4	+ .2	-1.2	-1.2	+1.0
1914....	-1.8	-.1	-.1	-2.5	-1.7	-.6	-1.4	0	-1.7	-.5	+ .4	+ .8
1915....	+3.9	+4.0	+4.3	+4.3	+4.7	+2.4	+1.0	+1.4	-.6	-1.0	+ .4	+3.2
1916....	+4.1	+4.3	+6.2	+4.6	+2.2	+2.1	+1.6	....	....	....	....	-1.7
1917....	+ .7	-.3	-1.1	+ .5	-.6	+ .4	+1.3	+1.5	+2.1	+1.0	+1.1	+1.3
1918....	-.5	-.2	-2.6	-3.0	-2.4	-.2	-.3	+ .5	+ .2	+ .2	-.9	-2.2
1919....	-1.6	-1.6	-1.5	+ .4	-1.3	-.8	-.9	-1.1	-1.0	-.7	-.6	+ .7
1920....	+ .6	-.2	-1.6	-.4	+1.0	+ .3	+ .8	+ .6	-.4	-1.0	-1.9	+ .8
1921....	-.7	+1.0	+ .5	+ .3	+ .3	+ .7	-.9	-1.0	-.6	-.5	-1.4	+ .3
1922....	+ .1	-3.2	-1.0	0	-1.3	-.9	+ .6	+ .4	+ .9	+1.3	+ .4	+2.0
1923....	+ .3	-.7	-1.0	-.5	+ .1	+ .2	0	+ .8	+1.1	+1.1	+1.0	-1.6
1924....	-.1	+1.5	-1.3	+ .3	-2.8	-3.4	-1.5	-1.7	+ .9	-1.0	+2.2	+3.1
1925....	+ .8	+ .4	0	-1.8	-1.6	-1.7	-.1	-.6	-.2	+2.2	+ .4	....
1926....	....	+2.8	+3.3	+ .2	+2.4	+1.6	+2.3	+1.6	+1.5	+2.3	+2.3	+1.9
1927....	+ .5	+1.8	+1.2	-1.1	+ .1	-.2	+ .2	-.8	+ .5	+ .4	+1.7	-1.4
1928....	+ .8	+ .3	+2.5	+ .3	-1.6	-1.0	-1.8	-1.2	-1.0	+ .2	+ .2	-.9
1929....	-1.5	-1.9	-.5	+ .5	-.3	+ .1	+ .7	+ .8	+3.1	+2.8	+ .1	-1.4
1930....	-.5	+2.7	-1.0	-2.4	-.4	-1.0	-1.3	-.2	+ .3	-.1	-.1	+ .8
Means..	77.8	78.4	77.8	78.2	80.1	81.2	82.0	82.4	83.1	82.5	80.6	79.2

Station: Kaanapali

1905....	-4.7	-.8	+ .1	-.7	-.4	0	0	-3.5	-8.6	-7.6	-6.8	-7.1
1906....	-6.2	-5.4	....	-6.7	-1.4	-.4	-.4	-1.5	-.1	0	-1.0	-1.1
1907....	-.9	-.6	-1.8	-2.2	+ .2	-.4	-.6	-1.4	-1.1	-1.8	-1.2	+ .5
1908....	0	+ .9	+ .4	0	-1.3	-2.6	-2.3	1.5	-1.2	-1.3	-2.1	-1.0
1909....	-1.0	-.9	-2.2	0	+ .7	-.5	-2.1	-2.0	-1.4	-1.5	-.2	-1.8
1910....	-3.7	-1.9	+ .4	-.4	-2.4	-2.2	-2.4	-1.6	-.7	-2.3	-.3	-1.1
1911....	-2.1	-2.0	-1.5	+ .8	0	-1.0	-.1	+ .1	-1.1	-1.4	-.5	-.5
1912....	+ .5	-1.4	-4.7	-.3	-1.1	-1.2	-.6	-1.0	-.3	-.5	-.5	+1.0
1913....	+1.5	+ .1	+1.9	+1.0	-1.8	-.1	+ .2	+ .2	+ .1	+ .5	+ .1	+ .2
1914....	-2.4	+ .8	-.1	-.4	-1.0	-.4	+ .6	-.6	-.9	-1.0	-.9	-1.9
1915....	-.4	-2.6	+ .5	+1.2	+2.2	....	....	....	....	....	....	-.1
1916....	-1.2	+1.3	-.2	+1.7	-1.6	-1.3	-.9	-1.0	-.2	+ .1	+ .1	-1.5
1917....	+ .1	-.9	+ .8	+2.5	+1.8	+1.5	+1.5	+1.1	+ .9	+1.3	+ .6	+1.2
1918....	+ .4	-1.3	-1.5	-3.3	-.7	+ .6	+ .5	+ .8	+1.3	+1.0	-.4	-.1
1919....	-.2	+ .6	+ .6	+4.0	+ .7	+2.1	+1.3	+ .4	0	+ .5	+1.5	+ .5
1920....	+1.1	+1.5	+1.0	+2.1	+3.5	+1.6	+1.5	+ .9	+ .7	+ .6	-1.0	+ .4
1921....	-.4	+1.4	+ .9	+2.7	+1.1	+2.1	....	+1.5	+ .4	-1.6	-1.1	-1.1
1922....	-.2	-1.2	+ .6	+2.4	-1.4	-.2	+ .3	-.8	-.4	-.6	-.2	+2.8
1923....	+ .5	-2.1	-.9	-.3	-.5	-.7	-.1	-.5	-.1	+ .9	+ .4	-.2
1924....	+ .6	+1.1	0	-.8	0	0	-.8	-.9	-.3	-1.5	-.3	+1.0
1925....	+1.7	+3.1	+ .2	-1.7	-1.4	-1.7	+ .1	-.3	+1.0	+ .9	+1.2	-2.3
1926....	+ .5	+3.9	+ .2	-1.6	+ .2	0	-.2	+ .3	-.2	+ .9	+1.3	+ .9
1927....	+5.6	+3.0	+3.5	-1.4	+1.4	+1.6	-.1	+1.5	+2.1	+2.8	....	+5.9
1928....	+1.7	-3.5	+ .8	-2.3	....	....	+ .9	+1.8	+2.4	+4.7	+8.4	-.5
1929....	+7.2	+2.1	....	+3.5	+2.3	+1.8	+ .2	+2.7	+3.2	+3.2	+ .9	+ .5
1930....	+2.3	+4.7	+1.7	+1.3	+1.5	+1.1	+2.9	+3.7	+4.1	+2.5	+ .8	+4.4
Means..	79.9	80.7	81.3	82.3	85.6	87.2	88.3	89.2	88.9	87.6	84.5	81.6

TABLE E

DEPARTURES FROM AVERAGE OF MEAN MAXIMUM TEMPERATURE

Station: Wailuku

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	— .2	+1.9	+1.5	+ .6	+1.7	+2.2	+2.7	+2.1	+1.8	+ .4	+1.2	—1.5
1906....	—5.9	—6.5	—8.8	+1.1	+1.0	+2.4	+1.3	— .6	— .5	— .1	+ .9	— .7
1907....	+ .7	+ .4	—1.6	—1.6	+ .9	— .2	— .2	—2.7	—2.2	—2.8	—1.9	+ .5
1908....	+ .9	+1.2	+2.4	+1.2	+ .1	—1.6	—1.7	—1.9	—2.0	—1.5	—1.4	—1.7
1909....	+ .4	—1.4	—2.3	— .9	—1.2	— .2	—1.2	— .6	— .9	—1.3	+ .3	0
1910....	—2.1	—1.7	— .2	— .1	— .6	—2.3	— .5	—2.0	+ .5	—1.4	+ .8	—2.4
1911....	—2.5	—1.7	—1.1	— .6	—2.2	3.1	—2.3	— .6	—3.1	—2.9	—2.5	—2.5
1912....	+ .7	—2.1	—3.8	—3.4	—1.7	—1.4	— .2	+1.3	+1.6	— .2	—1.4	— .8
1913....	+1.1	—1.3	+ .6	+ .1	+1.0	+1.9	+3.1	+2.4	—1.1	—3.5	—6.0	—6.4
1914....	—6.8	—5.0	5.1	—4.1	—7.4	—7.7	—6.5	—1.5	—3.1	—3.3	—3.2	—4.4
1915....	—3.8	—4.8	— .1	—4.1	—4.9	—6.2	—7.1	—7.1	—3.1	—2.2	—1.9	— .5
1916....	— .6	+2.4	+1.5	+2.1	— .4	0	— .2	— .4	— .2	+ .2	+ .2	—1.4
1917....	+1.9	+1.3	+1.4	+2.9	+1.9	+1.1	+1.1	+1.2	+ .9	+1.6	+1.1	+2.6
1918....	+1.4	— .7	—2.8	—4.4	—2.6	—2.1	—1.6	— .9	— .7	+ .6	— .6	—1.6
1919....	— .3	+1.8	+ .6	+1.7	+ .2	+2.8	+ .1	0	+ .8	+1.7	+1.8	+2.4
1920....	+2.1	+2.2	+ .7	+1.2	+3.7	+1.2	+1.4	+ .9	+ .6	+ .2	— .1	+1.2
1921....	+ .4	+2.4	+ .9	+1.4	+1.9	+1.4	+ .2	+ .2	— .6	+ .4	— .6	— .5
1922....	+ .1	—1.2	+1.0	+1.5	+ .4	+1.7	+1.8	+ .7	— .5	+ .5	+ .2	+2.3
1923....	0	— .2	— .1	+ .6	+ .7	—1.0	— .7	+ .4	+ .4	+ .4	— .1	—1.0
1924....	+1.2	+1.2	+ .8	+ .1	+ .5	+1.3	0	—1.1	+ .2	— .6	+ .8	+2.8
1925....	+1.9	+2.0	+ .3	— .5	— .1	— .5	+1.6	+1.3	+1.7	+2.7	+1.0	+3.2
1926....	+3.1	+3.7	+3.8	+ .2	+1.7	+2.6	+2.5	+1.9	+2.1	+2.7	+2.3	+4.6
1927....	+2.7	+2.6	+2.2	0	+2.1	+1.9	+1.6	+ .3	+1.3	+1.7	+3.3	+1.8
1928....	+1.7	+ .8	+3.1	+2.3	+1.4	+2.2	+1.3	+2.0	+1.0	+2.0	+1.6	+1.0
1929....	+1.0	+ .1	+2.7	+2.9	+2.4	+1.9	+2.7	+3.0	+3.4	+1.3	— .2	—1.2
1930....	+1.1	+3.5	+1.4	—1.1	+ .7	+ .5	+1.9	+1.9	+2.5	+2.8	+3.3	+3.3
Means..	77.6	78.3	78.5	79.5	81.6	83.1	83.9	84.7	85.0	83.9	81.3	78.9

Station: Ewa Mill

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	—5.1	—4.2	—3.8	—3.9	—3.9	—3.8	—3.8	—4.4	—4.7	—5.1	—3.5	—4.6
1906....	—4.2	—3.5	—4.2	+1.1	+ .5	+ .5	+ .3	+ .1	+ .5	+1.0	+1.1	+ .1
1907....	+1.5	+ .4	—1.3	— .7	+ .7	+ .6	— .1	— .6	+ .4	— .2	— .1	+1.3
1908....	+ .7	+ .5	— .3	— .7	— .1	—1.0	—1.1	— .8	—1.2	—1.1	0	—1.0
1909....	— .4	—1.2	—2.9	—1.1	— .4	— .1	— .8	— .7	— .3	— .4	+1.0	— .1
1910....	—1.0	— .8	+1.1	—1.1	—1.1	—1.3	— .5	— .7	—1.0	—1.1	— .6	— .9
1911....	—1.8	—1.7	— .4	+ .6	0	— .7	— .4	+ .9	— .9	—1.1	— .3	— .5
1912....	+ .5	— .3	—1.3	+ .4	+ .4	— .2	+ .4	+ .9	+ .8	+ .8	0	+ .9
1913....	+2.0	— .3	+1.6	+1.2	— .2	— .1	+1.3	+1.4	+1.1	+1.6	+ .6	+1.0
1914....	— .7	+1.0	— .4	+ .4	— .2	+ .3	+ .3	+1.4	— .1	+1.0	— .2	—1.4
1915....	— .7	—2.2	+ .3	— .2	+1.2	+1.7	+1.2	+1.7	+1.3	+ .2	—1.1	— .9
1916....	— .9	+ .8	+ .2	+ .5	—1.3	—1.9	—1.6	—2.5	—2.2	—1.7	—1.2	—1.4
1917....	— .4	—1.3	—1.0	— .7	— .3	— .6	— .1	— .3	+ .1	+ .1	+ .1	+ .4
1918....	+2.0	— .7	—1.3	—3.4	—1.3	—1.2	— .2	— .5	— .2	+1.2	+ .7	— .6
1919....	0	+ .4	+ .1	+ .5	0	+ .7	+ .4	+ .7	0	+ .1	+1.0	+1.0
1920....	+ .7	+1.6	+1.2	+ .4	+ .9	+ .2	— .1	+ .4	+ .9	+ .9	+ .3	0
1921....	— .3	+1.2	+1.3	+ .8	+ .2	+1.3	+ .7	— .1	— .2	— .9	— .3	+ .1
1922....	+ .7	—1.4	+ .5	+1.0	— .6	+ .3	+ .9	— .1	— .1	— .2	+ .3	+2.1
1923....	+ .3	0	+ .4	+1.3	+1.5	+1.5	+1.4	+1.7	+1.3	+2.0	+1.1	+ .1
1924....	+1.1	+1.7	+1.4	— .2	+ .8	+ .4	+ .6	+ .1	+ .7	+ .4	+ .5	+1.5
1925....	+2.9	+4.4	+1.9	— .4	— .3	— .7	+ .2	— .3	— .2	+ .9	+ .7	+1.3
1926....	+2.2	+1.4	+2.2	— .8	+1.1	+ .4	+1.3	+ .7	+ .8	+ .4	+ .5	+1.7
1927....	+1.4	+1.4	+1.0	+1.0	+ .4	+ .7	—2.8	0	+ .6	0	— .6	+ .1
1928....	+ .2	+ .4	+1.6	+1.7	— .1	+ .5	+ .2	+ .1	+ .2	+ .1	— .2	+ .1
1929....	+ .2	0	+1.3	+2.1	+ .5	+ .9	+1.5	+1.2	+1.2	+ .7	— .5	—1.1
1930....	+ .1	+1.9	0	— .4	+ .8	+1.0	+1.0	+ .6	+ .5	+1.1	+1.5	....
Means..	78.6	79.6	79.9	81.6	83.7	85.3	86.2	86.8	86.6	85.2	82.5	80.2

TABLE E

DEPARTURES FROM AVERAGE OF MEAN MAXIMUM TEMPERATURE

Station. Kahuku

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	-3.6	-2.5	-1.2	-1.0	-.2	-.5	-.8	-.7	-2.0	-2.4	-1.0	-2.7
1906....	-.8	-.7	-2.7	+.7	+.1	+.3	0	-.6	-1.0	-.6	-.3	-1.5
1907....	+.2	-1.3	-2.3	-2.3	-.2	-.2	-.5	-1.8	-1.3	-2.2	-1.4	-.5
1908....	-1.0	-1.5	-.5	-1.4	-.9	-2.2	-2.5	-2.4	-3.3	-3.2	-1.6	-2.3
1909....	-1.0	-2.5	-3.8	-2.1	-2.1	-1.9	-2.7	-2.9	-2.8	-3.4	-1.8	-2.1
1910....	-2.6	-2.9	-.7	-1.7	-2.4	-2.7	-2.1	-3.1	-1.9	-2.3	-2.0	-2.3
1911....	-2.2	-2.6	-.5	-.5	-1.2	-2.2	-1.9	-1.0	-2.2	-2.8	-1.7	-1.8
1912....	+1.4	-.8	-1.6	-.7	-.4	-.9	-1.0	-.7	-.8	+.6	+1.2	+1.3
1913....	+2.4	+2.1	+2.2	+.6	0	-.9	+.1	+.7	+.5	+3.5	+.8	+2.3
1914....	-.2	+2.8	+.8	-.3	-1.2	-.7	-.1	-.1	-1.7	+.1	+1.3	+2.7
1915....	....	....	....	+2.1	+.9	+.9	0	-.3	-.6	-.7	-2.5	+.8
1916....	+.6	+1.5	+.9	+3.5	+.5	-.7	-.9	-.8	+2.7	+2.7	+1.7	-.1
1917....	+1.9	+4.1	+.8	+1.7	+2.0	+.5	+1.1	+1.9	+2.4	+2.3	+1.9	+1.3
1918....	+1.6	-.4	-1.2	-1.8	-.5	+.1	+.8	+1.3	+2.1	+1.8	+1.8	-.6
1919....	+.3	+.3	+1.3	+1.8	+1.8	+2.8	+2.0	+2.8	+1.8	+1.8	+3.4	+2.0
1920....	+2.1	+4.0	+1.5	-2.0	-2.9	+.6	+3.8	+1.4	+3.2	+3.8	....	+6.4
1921....	+1.3	+3.3	+2.8	+1.3	+3.2	+3.5	+2.3	+1.8	+.9	+1.3	+1.5	+.2
1922....	+3	-1.4	+.4	+1.6	+.2	+1.1	+.4	+.5	0	+.4	+.7	+2.5
1923....	-.5	-.4	+.3	+1.9	+1.6	+1.2	+1.4	+2.7	+1.7	-1.3	+.4	-2.0
1924....	-.1	-.1	+.5	-.1	+.1	+.8	-.7	-.8	-.6	-1.8	-.6	+.1
1925....	-.1	+.1	-.1	-1.7	-1.0	-.9	-.2	+.1	-.4	+.9	-.5	+.8
1926....	+1.0	+.2	+1.3	+.2	+1.4	+1.1	+.9	+.5	+1.3	+1.0	+1.4	+1.2
1927....	+.2	+1.4	+.8	+.2	-.1	+.4	-.5	0	+.3	+.4	-.3	-1.6
1928....	-.3	-1.0	+1.8	+1.0	+.2	-.3	-1.2	-.3	-.6	-1.1	-1.4	-1.4
1929....	-.5	-.8	+.7	+1.4	+1.4	+.8	+1.2	+1.6	+2.3	+1.7	-.8	-2.4
1930....	-1.0	+.2	-1.0	-1.2	+.1	+.1	0	+.5	-.5	+.3	+.5	+.4
Means...	77.8	78.7	78.1	78.9	80.7	82.5	83.7	84.4	84.6	83.8	81.2	79.6

Station: Waiaua

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	+.5	+2.5	+1.9	+3.2	+1.7	-.4	-1.4	-.6	-.9	+.2	+1.5	-.2
1906....	+.7	+1.2	-1.9	+2.0	+.2	+1.3	+.7	+.2	+1.3	+2.5	+1.8	-.8
1907....	+1.0	+.6	-1.9	-2.4	+.4	+2.2	+1.0	+.4	+2.9	+1.5	+1.7	+2.6
1908....	+1.0	+2.0	+1.2	+.5	+1.5	-.9	-1.5	-.6	-1.9	-.4	-.1	-.3
1909....	+1.6	-.7	-2.4	-1.3	-1.6	-1.3	-2.4	-1.7	-.4	-.7	+1.9	-.2
1910....	-1.2	-.9	+.7	-.5	-1.9	-3.1	-1.3	-1.5	-.4	-.7	+.7	-.3
1911....	-.9	-2.0	+.4	+.1	-1.4	-2.3	-2.5	-1.7	-2.3	-1.1	0	-.3
1912....	+1.2	-.8	-2.4	-.5	-.2	+.3	+1.0	+.9	+1.0	+1.6	-.3	+.2
1913....	+1.2	-1.1	+1.1	+.8	-.1	-1.1	+.4	+1.1	+1.5	+.9	0	-1.2
1914....	-2.9	+.9	-1.0	-1.2	-1.2	0	+.2	+.6	-.5	-1.0	-.6	-2.5
1915....	-1.3	-2.9	+.7	-1.5	+1.5	+.5	+1.0	+2.7	+2.1	+.9	-.5	+.2
1916....	-1.3	+1.6	+2.0	+2.1	-1.3	-.6	-.4	-1.0	-.4	-.7	0	-.4
1917....	-.7	-2.0	-.5	+1.6	+.1	-1.2	-1.1	-.1	-1.3	-.2	0	-.2
1918....	-.1	-.2	-.9	-2.7	+1.0	+2.3	+2.7	+.7	+1.6	+.2	+1.0	-.3
1919....	-.7	+1.1	-.7	+.5	-.1	+2.2	-.3	+.4	-.7	-.8	-.3	-.6
1920....	+.1	+.3	-1.3	-.6	+.3	-.1	-.1	+.8	+.1	+.5	-1.2	-.3
1921....	-2.0	+.7	-.6	+.1	+.1	+2.6	0	+.9	+.2	-.2	-.9	-.9
1922....	-1.1	-3.0	-1.8	-.2	-.5	-.8	+.5	+.1	-2.0	-.9	-.8	+1.4
1923....	-1.1	-3.9	-2.3	-.7	-.8	-.2	+.2	+.6	-.1	+.6	+.5	-1.0
1924....	-1.3	-.4	-.9	-.7	-.8	-1.4	-1.4	-.5	....	-1.3	+.3	+1.2
1925....	+1.2	+1.1	+.4	-.6	-2.4	-2.4	-3.2	-2.5	-4.6	-4.0	....	-.9
1926....	+1.8	+.9	+2.2	-1.3	+3.0	0	+.9	+1.0	+.2	-.7	+.4	+1.6
1927....	+.1	+1.2	+1.1	-.7	-.3	+1.9	+5.1	+4.7	+2.8	+3.7	-.8	+2.3
1928....	+3.7	+.9	+4.2	+3.2	+3.1	+4.3	+3.5	+3.1	+1.0	+.6	-2.8	-.3
1929....	-.9	+.3	+1.5	+1.4	+.7	+1.3	+1.3	0	+1.5	+1.9	-.6	-.6
1930....	+1.3	+1.8	+.1	-1.3	-1.6	-3.0	-3.0	-1.2	+.1	-.9	-.5	+.8
Means...	77.7	78.5	79.3	81.1	83.8	85.9	87.1	87.2	86.4	84.2	81.0	78.8

TABLE E

DEPARTURES FROM AVERAGE OF MEAN MAXIMUM TEMPERATURE

Station: Waianae

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	....	— .3	— .5	+ .3	+ .7	+ .5	— .9	— .2	+ .4	— .4	— .6	—1.0
1906....	— .6	0	—3.2	+1.2	+ .6	+2.4	+1.3	+1.2	+1.0	+1.2	— .9	—1.3
1907....	— .9	— .8	—2.1	—1.9	— .4	0	— .4	— .4	— .5	—1.4	—1.0	+ .2
1908....	— .6	— .1	—1.7	—1.3	+ .1	— .2	— .1	—1.4	—1.6	—2.3	—1.7	—1.0
1909....	—1.6	—1.8	—1.6	—2.1	....	....	—1.3	— .9	— .6	—1.0	+ .4	—2.1
1910....	0	— .3	+3.0	+1.2	—1.2	—2.1	....	—1.1	—3.6	—2.0	—1.4	—1.4
1911....	—1.4	—2.0	—1.3	— .2	—1.2	—1.3	—1.7	—1.2	—1.3	—2.1	—1.5	+ .3
1912....	+ .8	0	— .5	+1.6	+ .6	—1.0	—2.1	— .8	+ .8	+1.9	— .7	+1.8
1913....	+1.3	— .4	+2.2	+2.0	— .6	—1.3	— .3	+ .1	+ .5	+ .3	— .4	—1.2
1914....	—1.5	— .6	—2.1	—1.4	—1.2	+ .1	0	+ .4	— .5	+1.5	+ .6	—1.3
1915....	— .6	— .6	— .1	+ .2	+1.6	+2.4	+1.2	+1.7	+1.3	+2.2	— .8	—1.3
1916....	—2.2	— .9	+ .5	+2.0	+ .8	+ .7	0	— .8	+ .3	—2.4	— .3	— .3
1917....	—2.1	—2.4	—2.2	— .8	+ .3	+ .2	— .3	0	+1.5	+1.0	+ .9	— .5
1918....	— .8	—1.3	—1.5	—4.1	— .1	+1.5	+2.3	+2.2	+1.8	+2.2	+1.2	+4.1
1919....	+1.7	+1.4	+1.4	+2.0	+1.1	— .3	+ .2	+ .1	— .4	+ .3	+ .1	+1.2
1920....	—1.3	0	— .4	— .2	—1.1	— .6	— .4	— .2	0	+1.4	+ .9	—1.3
1921....	—2.7	0	— .7	0	— .8	+ .6	— .7	—1.5	—4.5	—5.9	—5.0	—1.7
1922....	—1.1	—1.6	— .4	+1.0	— .8	— .2	— .3	— .7	—1.0	—1.7	— .7	+1.4
1923....	— .2	—2.2	—1.0	+ .1	+ .9	+ .2	+ .2	—1.0	+1.4	+1.3	+2.2	+2.1
1924....	+1.6	+1.3	+2.7	—1.2	— .7	—3.8	+1.4	+ .6	+1.0	+ .6	+2.2	+1.9
1925....	+2.9	+3.3	+1.5	— .6	—1.3	—1.3	— .3	+ .8	+1.4	+3.0	+4.4	+1.0
1926....	+3.5	+2.6	+2.5	—2.0	+1.2	+ .7	+1.2	+ .9	+1.4	—1.4	+4.3	+6.1
1927....	+6.7	+4.4	+4.1	+3.1	+1.1	+1.5	0	+1.2	0	+1.8	+1.4	—1.9
1928....	+ .6	— .2	+1.4	+ .5	—1.1	+ .1	— .4	— .3	— .2	+1.1	—1.0	— .3
1929....	+ .8	+1.4	+1.2	+1.7	+1.8	+ .7	+1.4	+ .3	+1.2	+ .4	—2.7	—3.3
1930....	—1.4	— .1	— .8	— .8	+ .8	+ .6	— .1	+ .5	— .3	+ .6	— .3	+ .4
Means..	80.7	81.2	82.0	83.5	85.5	87.1	88.8	89.4	88.7	87.4	85.1	83.0

Station: Waimanalo

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	—2.5	+ .9	....	— .5	— .9	— .8	—2.3	—1.7	—1.6	+2.8	—2.0	—1.5
1906....	+ .4	+ .4	—2.5	— .3	+ .9	+1.7	+1.7	+1.3	+1.8	+2.3	+1.0	— .4
1907....	+ .9	+ .9	—1.5	— .6	+1.9	+1.3	+1.6	+ .1	+1.3	+ .7	+ .2	+2.4
1908....	+2.6	+1.4	+1.9	+1.5	+ .5	— .3	0	— .2	— .8	0	+ .7	+ .3
1909....	+ .9	— .7	—2.5	+1.0	— .1	+ .1	—1.5	+ .1	+ .6	— .9	+ .7	— .1
1910....	—1.6	—1.1	+ .3	— .2	— .8	—1.0	+1.0	+ .3	+1.2	—1.1	+ .2	—2.1
1911....	—1.8	— .8	+1.4	+1.0	— .2	— .7	+ .3	— .2	—1.3	—1.5	— .4	— .1
1912....	+2.4	— .9	—2.4	+ .1	+ .5	+1.7	+1.5	+1.1	+1.4	+ .2	+ .1	+ .8
1913....	+1.4	— .9	+1.3	+1.5	+2.0	+1.2	+2.4	+3.5	+3.2	+3.3	+ .8	— .1
1914....	—1.8	+2.4	+ .6	+1.9	0	+1.3	+2.2	—1.1	—1.5	+ .1	+ .3	+ .1
1915....	+1.2	—3.8	+1.3	— .9	+1.9	+2.4	+2.0	+3.0	+2.4	— .4	—1.7	— .7
1916....	0	+2.5	+2.5	+2.6	— .6	— .8	— .8	— .9	— .6	—1.1	0	—1.9
1917....	—1.3	—1.6	—1.2	+ .6	+2.1	+1.6	+2.3	+2.8	+2.9	+2.3	+ .4	+ .5
1918....	+ .3	— .9	—2.3	—3.8	—2.1	—1.4	—1.2	+ .1	+1.4	+ .9	+ .3	—1.4
1919....	—1.0	— .1	+ .8	+1.4	+ .4	+1.1	— .6	— .7	+ .1	+1.0	+2.9	+1.5
1920....	+ .5	+1.2	+1.0	+2.5	+5.7	+3.4	+1.6	+3.4	+1.5	+ .8	+ .1	+1.4
1921....	—1.1	+3.2	+3.2	+1.3	+2.7	+2.9	+1.6	+1.2	+ .4	+ .2	+ .1	— .2
1922....	— .4	— .6	+1.3	+1.7	+ .8	+1.4	+1.7	+1.3	+1.1	+1.2	+1.3	+2.6
1923....	+ .3	—1.4	+ .1	+1.4	+2.0	+1.3	+ .4	— .2	—2.6	—4.2	—3.8	—4.4
1924....	—1.2	—1.8	—3.1	—3.7	— .3	—1.6	—2.1	—3.2	—3.7	—3.7	+ .7	+2.7
1925....	+3.0	+ .6	— .7	— .8	—2.4	—3.0	— .7	— .2	— .2	+1.9	+4.2	+1.6
1926....	....	+4.4	+ .3	—3.2	—2.3	—2.9	—2.9	—3.4	—4.0	—3.0	—1.4	+1.6
1927....	— .1	—2.7	—2.0	—4.5	—6.3	—5.5	—3.4	—1.1	—2.3	—3.9	—4.0	—4.8
1928....	+ .6	—1.4	+2.8	+2.6	—3.1	—1.5	—2.6	—1.4	0	— .8	—1.2	—1.2
1929....	— .3	+ .4	+ .1	+ .5	—1.0	—1.2	—1.5	—1.4	— .4	+2.5	— .8	—2.2
1930....	— .4	+1.1	—1.8	—2.3	— .9	—1.8	— .9	—1.3	—1.4	— .7	— .3	+ .7
Means..	77.6	78.6	78.9	79.8	82.3	83.9	84.9	85.4	85.4	84.3	81.3	78.6

TABLE E
DEPARTURES FROM AVERAGE OF MEAN MAXIMUM TEMPERATURE

Station: Waipahu

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....												
1906....	+ .7	+1.0	—2.7	+2.7	+ .2	+2.2	+1.7	+1.0	+1.6	+1.8	+1.8	— .7
1907....	+1.3	+ .8	—1.6	— .6	+1.6	+1.9	+1.9	+ .9	+1.7	+ .4	+ .3	+3.3
1908....	+1.3	+ .3	— .7	+ .3	0	+ .4	+1.0	+ .7	— .3	+ .2	+1.2	0
1909....	— .6	—1.6	—1.7	— .6	+1.4	+1.4	+ .9	+1.1	+ .6	+ .2	+1.6	— .1
1910....	— .9	— .9	0	—1.2	—1.3	—1.3	+ .7	—1.2	— .9	—1.2	— .2	— .4
1911....	—2.1	—1.8	— .4	+1.0	— .7	— .3	— .4	+ .5	—1.2	— .7	— .6	—1.2
1912....	+ .7	—1.4	—2.7	—1.2	— .9	— .6	— .5	— .1	— .5	— .8	—1.7	0
1913....	+1.7	— .5	+ .5	— .8	— .4	— .9	+ .8	+1.1	+ .7	+1.4	—1.1	+ .4
1914....	—1.8	+ .9	—1.0	0	— .6	+ .4	+ .4	+ .7	—1.6	— .9	—1.1	—1.9
1915....	—1.2	—2.4	+ .3	+ .6	+2.1	+1.8	+1.4	+1.7	+ .6	—3.5	—2.2	—3.7
1916....	—1.1	+ .1	0	+ .9	— .7	—1.5	— .6	—2.4	—1.5	—1.7	—1.1	—1.2
1917....	— .9	—1.1	—1.9	—3.9	— .7	—1.0	+ .1	+ .3	+ .2	+ .4	+ .5	+ .5
1918....	+ .4	—1.4	—2.0	—3.3	—1.3	— .5	— .7	— .2	+ .5	+ .8	+ .2	— .8
1919....	—3.7	— .8	— .4	+ .9	— .2	+ .4	— .4	....	— .2	+ .5	+1.9	+3.8
1920....	+2.7	+1.9	+ .1	+1.2	+1.4	+ .7	+ .9	+1.2	— .2	+ .4	— .5	+1.6
1921....	—1.8	+1.5	+ .5	+ .5	+ .7	+2.3	+1.2	+1.0	— .3	+1.1	+ .5	— .5
1922....	— .7	—2.1	— .2	+ .9	—1.3	— .2	—1.0	+ .4	— .4	+ .2	+1.2	+2.0
1923....	—2.0	—2.1	—1.3	+ .5	+ .3	+ .9	+ .2	+ .3	+ .6	+ .4	— .6	....
1924....	....	....	—1.7	— .5	— .8	—2.3	—4.2	—5.0	—4.5	—3.9	—2.6	—2.1
1925....	+1.6	+ .6	+6.1	+ .5	— .4	—2.1	+ .2	+ .5	+2.4	+ .7	+2.5	+1.7
1926....	+4.0	+3.6	+5.5	— .6	+2.5	+2.3	+1.8	0	+1.5	+3.5	+2.9	+4.7
1927....	+3.2	+5.0	+3.4	+3.4	+1.7	+1.6	— .1	+ .5	+ .9	+ .9	+1.2	—1.6
1928....	— .2	+ .1	+1.9	+1.0	— .4	— .9	—2.5	—1.2	—1.5	— .8	—2.2	—1.4
1929....	— .2	+ .2	+2.6	+1.2	— .7	—1.6	—2.1	— .4	+2.2	+ .9	—2.7	—3.1
1930....	—1.5	+ .9	—1.7	—2.5	—1.8	—2.5	0	—1.4	— .8	+ .3	+1.5	+1.1
Means..	78.1	79.3	79.9	80.9	83.2	84.5	85.4	86.0	86.0	84.6	82.1	79.7

TABLE E
TEMPERATURE DEPARTURES FROM THE AVERAGE
BY MONTHS
MEAN MINIMUM TEMPERATURE

TABLE E
DEPARTURES FROM AVERAGE OF MEAN MINIMUM TEMPERATURE

Station: Hakalau

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	—2.4	—1.4	0	+1.3	....	+ .7	+3.5	+3.5	....	+2.7	+2.4	+1.6
1906....	+4.6	+2.1	—1.7	— .5	—1.2	0	+ .2	....	....	....	....	....
1907....	— .3	— .8	—2.6	—3.3	—2.3	—1.8	— .2	— .5	+ .4	— .2	— .8	— .7
1908....	—2.0	— .6	+ .2	—2.0	—1.7	—2.3	—1.8	—1.6	—1.2	—1.3	— .4	—2.3
1909....	—2.0	—1.1	—1.7	—2.0	—3.2	—1.9	—2.6	—3.7	—3.0	—2.4	—2.6	—2.5
1910....	—2.3	—2.1	—1.6	—2.1	—2.9	—2.7	—3.2	—2.7	—1.4	—3.1	—1.5	—1.6
1911....	—1.2	— .6	—1.1	0	—2.2	—1.4	—1.9	—1.2	—1.4	—2.1	—1.8	—1.3
1912....	—1.8	— .9	—2.2	—1.7	—2.1	—2.6	—2.3	— .5	—1.1	— .5	—1.3	— .6
1913....	+ .8	— .1	— .9	—2.3	—2.5	—1.2	—1.1	— .3	+ .2	+ .7	—1.1	—2.1
1914....	—2.0	0	+ .7	+3.0	+1.5	+1.5	+2.8	+3.0	+2.9	+3.3	+4.1	— .8
1915....	+ .6	+ .3	+1.3	+1.3	+3.7	+1.9	+1.5	+ .7	+1.0	+ .5	+1.4	+2.7
1916....	+3.1	+3.5	+3.8	+2.8	+ .9	+ .7	— .3	— .8	+ .2	+ .5	+ .2	+ .7
1917....	+1.8	+1.3	+2.0	+1.2	+ .2	+1.1	+ .1	+ .2	+1.2	+1.0	+ .9	+2.1
1918....	+1.9	+2.3	+1.0	+1.9	+11.7	+2.2	+1.8	+1.9	+1.7	+1.0	+ .5	+ .5
1919....	— .3	— .1	0	+ .7	— .9	— .5	— .5	— .3	+ .5	+3.8	+2.2	+1.6
1920....	+2.7	+2.5	+1.4	+1.1	+1.7	— .8	—2.2	—4.1	—4.7	—6.3	—7.7	—6.3
1921....	—6.8	—7.0	—8.7	—6.0	— .1	+ .7	— .3	—1.2	—2.5	—1.8	—3.3	—2.2
1922....	—3.3	—6.1	+1.2	+1.3	— .6	— .1	+ .4	+ .2	+ .2	+ .4	+ .7	+1.0
1923....	+ .8	+1.4	+ .8	+1.7	— .3	+ .9	+ .5	+ .7	+2.0	+1.8	+1.2	+1.1
1924....	— .7	+2.4	+1.0	+1.1	— .2	— .1	0	— .3	+1.0	—1.3	+ .8	+3.9
1925....	+1.0	+1.9	+1.4	— .1	— .9	— .8	— .2	+1.2	+1.2	+ .8	+1.9	+ .7
1926....	+1.1	+ .9	+1.1	—2.4	—1.9	+1.6	+1.8	— .9	—2.9	—2.8	— .9	+1.7
1927....	+ .8	— .1	0	+ .5	+ .2	+1.7	+ .1	+ .3	—1.2	—1.2	+1.8	+ .5
1928....	+1.2	0	+ .9	+2.1	+2.3	+1.8	+ .4	+2.7	+1.8	+1.0	+1.7	+ .7
1929....	+1.8	+1.2	+2.6	+1.9	+2.1	+2.0	+2.7	+2.4	+3.4	+2.8	+2.5	+1.7
1930....	+1.5	— .2	+2.0	+ .2	+ .1	+ .4	+ .7	+ .9	+2.7	+1.8	....	....
Means..	63.0	62.6	63.2	64.5	66.2	66.9	68.0	68.6	68.0	67.6	66.1	64.6

TABLE E

DEPARTURES FROM AVERAGE OF MEAN MONTHLY MINIMUM TEMPERATURES

Station: Hilo

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	— .4	—2.3	— .4	+1.5	+2.5	+2.2	+3.4	+2.7	— .9	....	0	—1.0
1906....	— .4	— .2	—1.9	0	— .4	— .4	— .5	— .5	— .4	— .5	—1.1	— .1
1907....	+ .2	+ .3	— .8	—1.9	— .8	— .1	— .9	— .4	— .5	— .9	—1.4	—1.1
1908....	—2.8	—2.5	+ .4	—1.6	—1.0	—1.7	— .5	—1.4	—2.5	—1.1	—2.2	—2.4
1909....	—2.2	—1.6	—2.2	—1.2	—2.6	—1.6	—2.9	—2.2	—1.6	— .7	+1.2	— .4
1910....	0	—2.6	—2.3	—2.6	—2.5	—2.7	—2.1	— .7	— .8	....	....	— .5
1911....	— .8	+ .1	— .5	+1.0	— .6	— .2	+ .4	— .2	— .8	— .8	— .9	—1.8
1912....	+ .5	+1.0	—1.8	— .8	—1.1	—1.1	— .8	+ .3	— .3	— .2	— .3	+ .3
1913....	+ .4	+ .1	— .5	—1.0	— .8	+ .1	— .3	+ .1	+ .5	+1.3	+ .9	+ .6
1914....	— .8	0	— .2	— .4	+1.5	+1.0	— .4	— .3	+1.8	+1.3	+ .1	—1.4
1915....	+ .4	—1.1	— .2	— .5	+2.1	+1.0	— .2	+ .2	+ .5	— .1	+2.3	....
1916....	+ .8	— .1	+2.3	+ .2	—1.4	—1.5	—2.7	—3.2	—3.6	—3.2	—3.3	— .9
1917....	— .7	—1.6	0	— .6	—1.6	—1.0	—1.9	—3.7	—3.0	— .8	—2.0	—1.1
1918....	+ .4	+1.7	+2.7	+1.4	+ .4	— .8	+ .8	+ .5	— .2	+ .1	0	+ .3
1919....	—1.8	— .8	+ .1	— .1	— .8	+ .2	— .5	+ .6	— .4	— .2	— .8	— .5
1920....	— .4	— .3	—1.6	— .6	+ .6	— .1	+ .6	+ .1	— .4	—1.4	—1.5	+ .7
1921....	+1.5	+ .2	+ .3	+ .8	+ .4	+ .3	— .9	+ .4	— .1	+ .2	— .2	+1.2
1922....	— .2	+ .4	+ .6	+ .8	+ .2	— .2	+ .8	0	+ .2	+ .2	+ .3	+ .5
1923....	+1.4	+ .3	+1.0	+1.6	+ .3	— .4	+ .9	+ .6	+1.8	+1.1	+ .5	+1.4
1924....	—1.2	+2.4	—1.0	+1.5	+ .5	— .9	— .1	+ .2	+ .2	+ .4	+ .6	+1.3
1925....	+ .5	+1.4	0	— .5	+ .5	+ .8	+ .4	+ .7	+1.4	+1.6	+1.3	+ .5
1926....	+ .5	+1.2	— .6	— .8	+ .5	+1.5	+2.1	+1.5	+2.1	+1.7	+1.4	+1.4
1927....	+1.8	+1.5	+1.6	+1.7	+1.6	+1.6	+1.1	+ .6	+ .7	+ .6	+1.6	+1.0
1928....	+1.2	— .4	+1.1	+1.3	+1.1	— .4	+ .3	+ .6	+1.0	+ .4	+ .9	— .1
1929....	+ .4	+ .5	+2.3	+ .9	+ .7	+1.3	+1.5	+ .9	+1.2	+1.3	+ .8	+ .3
1930....	+1.3	+1.8	+1.4	0	0	+ .5	+1.1	+1.6	+2.5	+ .7	+1.0	+1.3
Means..	62.5	62.2	63.0	64.2	65.2	66.4	67.4	68.1	67.5	66.9	65.7	64.0

Station: Honokaa

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	—2.1	— .7	— .5	— .5	— .2	— .7	— .2	+ .9	+ .6	— .3	+ .1	— .9
1906....	+ .6	— .1	—1.6	+ .1	+ .1	+ .1	—1.1	— .6	— .8	+ .2	— .4	— .9
1907....	+ .6	—1.1	— .4	—1.9	— .1	+2.2	+1.1	+1.4	+ .3	— .5	+ .6	0
1908....	— .4	— .2	— .2	— .2	— .7	— .2	— .3	+ .5	+ .2	— .1	—1.3	+ .2
1909....	+ .3	— .6	— .3	— .6	— .4	+ .1	+ .4	— .4	— .6	+ .2	+ .1	— .7
1910....	+ .7	+1.1	+2.2	+2.9	+1.4	— .5	—2.7	—1.7	+ .5	+ .3	+ .7	— .6
1911....	— .9	—1.1	— .7	— .7	—1.1	—1.9	—2.1	—1.3	— .3	— .7	+ .6	+ .3
1912....	0	+2.6	+ .7	+2.3	+3.0	+3.3	+4.1	+2.4	+ .4	+1.8	+ .4	+1.8
1913....	+ .9	0	+ .1	—1.3	—2.5	—1.0	—1.5	—1.2	—1.4	— .4	— .5	—1.7
1914....	—2.7	—2.4	—2.3	—1.0	— .9	— .7	— .1	— .2	+ .4	—1.1	— .7	—2.8
1915....	—2.1	—3.3	—2.8	—1.8	— .7	—1.1	—1.8	—1.3	— .6	— .8	—1.9	—1.8
1916....	—1.2	— .7	+1.0	— .1	— .8	—1.8	—2.5	—3.2	—2.0	—1.3	—1.8	—2.2
1917....	—2.4	—3.1	—1.7	—2.1	—2.5	—1.6	—2.6	—2.5	—2.0	—1.6	—1.7	—1.1
1918....	—1.7	—1.8	—3.5	—2.1	—2.0	—1.6	—1.1	— .1	—2.1	—2.7	—1.6	—1.6
1919....	—3.4	—2.6	—3.9	—3.5	—3.5	—2.7	—2.5	—2.3	—2.8	—2.4	—2.4	—1.9
1920....	—1.6	— .1	— .2	— .3	— .1	+ .9	+ .7	+2.0	+1.7	+ .6	—1.5	+1.0
1921....	+1.9	+ .8	+ .7	— .9	+ .2	+ .8	+ .4	+1.6	—1.2	—1.5	— .8	+ .2
1922....	— .1	— .2	+ .8	+2.0	+ .5	— .4	+1.4	+ .5	+ .4	0	—1.9	—1.5
1923....	0	— .6	0	+ .9	— .1	— .5	—1.0	—2.1	—2.3	—1.4	— .3	+ .9
1924....	+ .4	+2.6	+ .2	+2.2	+ .8	+1.3	+1.3	+1.1	+1.3	+2.1	+1.7	+2.3
1925....	+2.9	+2.5	+1.0	+ .3	+ .6	+1.1	+ .4	+1.6	+1.9	+1.4	+1.9	+1.2
1926....	+1.9	+2.1	+1.4	— .4	+1.9	+1.1	+1.9	+2.5	+2.4	+2.5	+1.4	+2.4
1927....	+2.3	+2.6	+3.1	+2.1	+2.3	+1.9	+1.7	+1.4	— .8	+1.3	+2.7	+2.8
1928....	+2.3	+ .5	+1.2	+1.9	+1.4	— .2	+ .5	+ .7	+1.0	+ .8	+2.1	+1.6
1929....	+1.8	+1.0	+1.6	+2.1	+1.5	+1.4	+2.9	+2.2	+2.6	+3.7	+2.0	+2.1
1930....	+1.9	+3.0	+2.0	+1.4	+1.1	+1.5	+1.7	+3.2	+2.7	+ .8	+2.0	+1.0
Means..	61.0	60.8	61.8	62.7	64.5	65.7	66.6	67.3	66.7	65.8	64.1	62.6

TABLE E

DEPARTURES FROM AVERAGE OF MEAN MINIMUM TEMPERATURE

Station: Kohala Mill

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	-4.0	-1.6	+1.1	+ .2	+ .2	-1.9	-1.1	+ .9	- .4	- .5	- .4	- .6
1906....	+1.4	- .2	-1.3	0	-1.2	+1.2	0	- .5	+1.3	+1.1	0	- .3
1907....	+1.2	+ .7	- .7	-1.4	+ .3	+1.7	+ .3	+ .8	+ .5	- .1	- .1	+ .7
1908....	+ .2	- .3	+ .5	- .1	+ .1	-1.4	-1.6	-1.3	-1.7	- .9	-2.0	-1.4
1909....	- .9	-1.8	-1.8	-1.8	-1.5	+ .2	- .7	- .1	- .2	- .5	- .1	- .5
1910....	-6.3	-1.5	+ .3	+ .4	- .7	- .4	- .7	- .4	-1.3	- .9	0	- .8
1911....	+ .7	- .9	0	+1.2	+ .6	+ .5	+ .4	+ .3	- .3	-1.6	+ .5	0
1912....	- .1	+ .4	- .5	+ .7	+ .4	- .3	+ .5	+ .8	+ .2	+1.6	+ .9	+2.1
1913....	+1.5	+ .5	+ .5	+1.0	- .1	+ .8	+1.0	+1.1	+ .4	+1.5	+1.4	+ .6
1914....	- .3	+ .3	+ .1	+ .4	+ .5	+1.3	+1.4	+1.8	+1.4	+ .2	- .3	- .6
1915....	+ .4	-1.1	- .7	+ .5	+ .9	+ .8	+ .5	+ .2	+ .8	+ .8	+ .4	- .2
1916....	+1.3	+ .7	+1.5	+1.1	+ .3	- .9	-1.0	-2.6	-2.5	- .6	- .9	- .9
1917....	- .7	-1.7	- .7	- .5	-1.1	0	- .8	- .6	-1.4	-1.4	-1.4	- .6
1918....	- .6	-1.7	-2.9	-5.3	-6.6	- .3	+ .8	+1.0	+ .3	+2.0	- .6	-3.1
1919....	-3.7	- .4	+ .8	+ .5	+1.2	+1.3	+1.7	+1.2	- .2	+1.0	+ .2	+1.0
1920....	+ .3	+1.4	+ .6	+1.5	+ .9	+ .1	+1.3	+ .2	+ .1	+ .0	+ .9	+ .2
1921....	+ .9	- .9	-2.3	-2.0	- .4	-3.6	-6.3	-6.2	-2.9	-7.4	+ .6	+1.9
1922....	+2.6	+1.5	+ .6	+1.9	+ .7	+1.5	+2.3	+1.4	+1.5	+ .9	-1.1	+1.2
1923....	+1.7	+2.0	+1.2	-1.1	-1.7	-2.7	-1.6	-1.8	- .6	- .7	-1.6	- .9
1924....	-1.5	+1.4	-1.6	0	- .6	-1.2	-1.5	-2.0	-1.4	-1.2	-1.3	-1.3
1925....	+ .3	0	- .2	- .3	- .4	- .1	- .5	+ .2	+ .3	- .3	- .1	- .3
1926....	+1.0	- .2	+ .3	-1.1	+1.1	- .3	+ .7	+ .6	+ .6	+ .6	- .5	+ .9
1927....	+1.7	+1.1	+2.2	+1.4	+1.9	+ .6	+ .2	+ .1	- .5	+ .1	+ .5	+ .7
1928....	+ .7	-1.3	-1.2	+1.0	+1.0	- .2	+ .9	+ .9	+ .5	+ .4	+ .7	+ .3
1929....	+ .9	+ .1	- .3	+ .9	+1.3	+ .6	+2.6	+1.4	+1.3	+2.0	+ .7	+ .2
1930....	+ .8	+4.6	+3.6	0	+3.4	+2.5	+1.3	+3.8	+3.7	+1.7	+3.4	+1.6
Means..	62.2	62.3	63.0	63.9	65.4	67.1	68.1	68.7	68.9	67.4	65.7	64.3

Station: Olaa Mill

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	-6.3	-10.2	-5.7	8.0	-11.5	-10.9	-7.5	-5.6	- .6	-4.8	-3.7	-3.9
1906....	-4.9	-7.1	-1.4	-1.5	-2.1	- .2	-3.7	-4.1	-3.6	-1.5	-2.9	-2.5
1907....	- .5	0	- .6	-1.7	+ .3	- .6	1.4	-1.6	+1.2	+1.6	+1.3	+1.3
1908....	+ .2	+1.3	+1.1	+ .2	- .3	- .9	+ .2	- .1	+ .6	+ .7	+ .5	- .3
1909....	-1.2	+ .6	-1.4	+ .1	- .8	+ .5	+ .7	- .4	-1.8	+ .9	+ .6	+ .2
1910....	+ .9	- .7	+ .2	+ .4	+ .3	- .2	- .2	+ .4	- .1	- .6	+ .7	- .4
1911....	+ .8	+1.1	+ .7	+1.8	- .2	+ .8	+1.2	+1.6	+1.0	0	- .4	-1.4
1912....	- .9	+1.2	+ .1	- .8	+ .1	+ .3	+ .7	+ .1	+1.2	+ .3	+ .3	+1.0
1913....	+1.5	+ .1	+ .6	- .8	+ .1	+ .7	+1.2	+1.2	0	+1.7	+ .9	+ .9
1914....	+ .2	+1.1	+ .6	+1.9	+1.7	+1.2	+2.9	+2.4	+3.0	+ .9	+ .9	- .8
1915....	- .1	+ .8	+ .6	- .1	+2.6	+1.6	+ .7	+ .6	+1.2	+ .7	+ .8	- .1
1916....	+3.0	+2.3	+2.3	+1.8	+1.3	+ .5	-1.0	-1.5	-1.5	+ .3	- .9	0
1917....	+ .5	+ .6	+1.7	- .6	+ .6	+ .5	- .7	-1.0	-1.2	- .3	+ .2	+ .3
1918....	+1.5	+1.3	- .1	+2.1	+1.4	+ .9	+2.2	+1.1	+ .5	+1.3	+2.2	+1.8
1919....	+ .8	+ .5	+ .1	+ .2	+ .3	+1.5	+ .1	+1.0	- .3	- .6	- .4	+1.0
1920....	+1.6	+ .9	- .4	+ .3	+2.1	+1.5	+1.7	+1.8	+ .3	0	0	+1.2
1921....	+2.7	+2.1	+1.1	+1.5	+1.7	+1.5	+1.1	+1.1	+ .8	- .1	- .1	+ .7
1922....	0	+ .6	+1.1	+2.0	- .1	+ .2	+ .3	+ .3	- .5	- .4	+ .1	- .9
1923....	+1.4	+1.5	+ .6	+ .9	+ .4	- .8	+ .2	- .3	+ .9	+ .7	- .2	+ .7
1924....	-1.9	+2.0	- .7	+1.8	- .6	- .9	-1.4	- .8	-2.1	- .8	- .9	- .5
1925....	- .7	0	-1.0	-1.7	- .4	-1.0	- .8	- .5	- .8	-1.0	- .1	- .2
1926....	-1.0	+ .1	-2.6	-2.6	- .6	- .2	- .2	- .7	- .7	- .2	-1.7	-1.3
1927....	- .1	-1.1	- .4	- .2	- .8	-1.0	-1.3	-1.3	-2.5	-1.5	-1.2	-1.1
1928....	-1.2	2.6	-2.2	+ .2	+2.2	+1.0	+1.7	+1.6	+ .2	+ .8	+1.8	+ .8
1929....	+1.4	+1.5	+2.7	+1.9	+2.0	+1.4	+1.9	+1.0	+1.3	+1.3	+1.0	+1.5
1930....	+1.6	+1.9	+2.1	+1.3	+ .9	+1.7	+2.0	+3.2	+3.1	+1.7	+2.1	+1.1
Means..	60.2	59.9	60.9	62.2	63.1	64.3	65.3	65.9	65.6	64.8	63.3	62.2

TABLE E

DEPARTURES FROM AVERAGE OF MEAN MINIMUM TEMPERATURE

Station. Ookala

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	-2.2	-1.5	-1.2	-.9	-1.0	-1.2	-.4	-.1	-1.1	-2.3	....	-1.7
1906....	-1.9	-1.7	-2.9	0	+.2	+.8	+1.1	+1.5	+1.4	+1.1	+.8	+.7
1907....	+1.0	-.4	-.6	-1.3	0	+.8	-.1	+.2	+.8	-.2	-.2	+.4
1908....	-1.2	-.6	+.3	-1.2	-1.1	-.9	-.3	-.5	-1.7	-1.0	-1.3	-.3
1909....	+.2	-1.3	-1.7	-1.7	-3.0	-4.5	-5.4	-3.1	-3.0	-1.7	-1.7	-2.3
1910....	....	-.5	-.1	0	-.9	....	....	....	....	....	....	-1.2
1911....	-1.2	-.5	-1.0	+.9	-.3	-.1	-.3	+.3	-1.6	-2.2	-1.1	-1.3
1912....	-1.9	-.5	-2.4	....	-.7	+.2	0	+.8	-.5	0	-1.1	-.8
1913....	+.1	-.3	-.4	-1.0	-.7	+.5	+.6	+1.1	-.4	+1.5	+.6	-.8
1914....	-1.6	-.1	-.4	+.2	+.5	+1.1	+2.0	+2.2	+1.6	+.2	+.3	-.9
1915....	-.2	-2.0	-.8	+.2	+2.0	+1.4	+.8	+1.6	+.6	+.1	-.2	0
1916....	+.8	+1.4	+1.7	+1.3	+1.2	+.1	-.6	-2.3	-1.7	-.2	-.3	+1.7
1917....	+2.7	-.8	-.4	+.2	-.4	+.3	-.5	+.5	-.8	-.7	-.6	0
1918....	-.4	-.6	-1.6	-.5	-.5	-.5	-.1	+.6	+.4	+.8	-.2	-.3
1919....	+1.4	+.2	-.3	+.3	+5.5	+8.6	+1.5	+.1	-1.5	+.3	+1.5	+2.8
1920....	-1.0	+.7	+1.1	-1.5	-1.7	+.2	0	+.4	-.4	-.3	-.8	+.3
1921....	+.6	+1.2	+.4	+.5	0	+1.4	+1.4	+.3	-.6	0	-1.8	-.7
1922....	-.2	+3.7	+5.9	+3.0	+.1	-7.3	+2.4	-.1	+3.3	+4.4	+4.9	+2.1
1923....	+1.2	+1.8	+1.3	+.6	+2.6	-2.1	-1.8	-2.1	+5.2	-.6	-.7	-.4
1924....	-3.4	-.7	-2.7	-.7	-.6	-.3	-.6	-.1	-.9	-.8	-.1	+.2
1925....	-.2	0	+.6	-.3	-.1	+.1	-.4	+1.1	-.4	-.1	-1.3	-.9
1926....	+2.1	+1.7	+.7	-1.4	-4.4	-2.8	-5.3	-5.4	+.8	-.9	-.9	-.2
1927....	-.4	+1.4	+.7	+.9	+1.7	+1.3	+1.5	+.6	0	+.9	+.5	+.6
1928....	+.5	-1.4	+1.0	+.7	+.9	+.5	+.9	+.8	+.2	-2.7	+.6	-.1
1929....	0	+.2	+2.3	+1.6	+2.1	+2.0	+3.0	+2.3	+2.2	+1.9	+.7	+1.1
1930....	+4.7	+1.7	+.5	+.1	-.6	+1.1	+1.3	....	....	+2.3	+2.0	+.9
Means..	62.7	62.3	62.9	63.6	64.8	65.8	66.4	67.2	68.0	67.0	65.8	64.4

Station: Pahala

1905....	-.8	-.6	-.2	-.7	+.2	-.1	+.6	+1.4	+.4	+.3	+.4	-2.6
1906....	-.4	+.1	-1.6	-.1	+.9	+.7	+1.3	+1.6	+.3	+1.1	+.5	+.8
1907....	+3.2	+1.0	0	-1.8	-.4	+.4	-.6	-1.2	+.1	-.6	-.7	-1.1
1908....	2.8	-.4	+.2	-1.4	-.7	-1.6	-2.0	-.9	-.5	-.9	-2.2	-1.9
1909....	-2.2	-.3	-1.9	-.8	-2.2	-.8	-.9	-2.2	-1.9	-1.3	-2.5	-1.9
1910....	-2.2	-3.0	-2.0	-2.2	-2.8	-1.6	-2.1	-1.5	-1.6	-1.6	+.6	-.3
1911....	+.7	+.8	+.8	+3.0	-.9	0	+.4	+1.0	+.6	-.7	-.3	-.3
1912....	-1.8	+.2	-2.6	-1.5	-1.1	-.2	0	+.5	+.6	+1.3	0	+1.3
1913....	+.8	-.7	-.3	-1.3	+.3	+.3	-.1	+.1	+.2	+1.7	+.5	-.3
1914....	-2.7	-1.5	-.7	+1.4	+1.4	-.1	-.3	+1.6	+1.4	-.7	-.7	-2.0
1915....	-1.1	-2.7	-1.2	-.6	+.8	+.6	0	-.1	-.1	-1.0	-1.1	-.1
1916....	+2.5	+1.8	+5.1	+1.0	+.2	-.9	+.2	-2.2	-.7	+.3	-1.5	-2.7
1917....	-1.3	-2.5	-4.3	-3.3	-.1	-1.9	-2.3	-2.9	-3.0	-1.5	-1.3	-.8
1918....	-.8	-.9	-1.5	+.5	-.1	+.3	+.2	-.5	-1.2	-.4	+.1	-.8
1919....	-2.7	-1.0	-.8	-.2	-1.1	-.2	-2.2	-.4	-1.1	-1.1	-1.6	-.6
1920....	+1.7	-.7	-1.7	-3.3	-2.6	-3.2	-3.6	-5.2	-6.6	-5.3	-2.9	+.3
1921....	+2.8	+1.1	-.1	-.2	-.8	-1.0	-.6	0	+.9	+.7	+.2	+1.8
1922....	+1.0	-.5	+.2	+1.4	+.4	+.4	+.3	-5.6	+1.7	+.9	+1.0	+.2
1923....	-.5	+1.6	+1.4	+2.1	+.4	+.2	+1.1	+.4	+1.1	+.7	+1.2	+2.5
1924....	-1.2	+2.1	+1.4	+2.5	+1.0	-.3	-.8	+.1	-.1	-.6	0	-.4
1925....	+.7	....	....	....	+1.0	+1.3	+1.1	+2.3	+1.1	+1.2	+1.3	+2.5
1926....	+1.4	+2.3	+.9	-.5	-1.2	+2.8	+1.9	+2.6	+1.2	+2.1	+.5	+2.3
1927....	+2.2	+2.0	+3.3	+1.2	+2.4	+2.0	+2.1	+1.7	+.9	0	+2.3	+1.8
1928....	+1.2	-.3	+.6	+1.1	+1.4	+.3	+1.9	+.6	+.9	+.6	+2.3	+.4
1929....	+.4	+.1	+2.1	+1.6	+1.5	+1.3	+1.3	+2.2	+2.4	+2.4	+1.8	+2.4
1930....	+3.0	+2.5	+3.0	+1.4	+1.1	+2.3	+2.4	+4.2	+3.7	+2.5	+3.1	+.4
Means..	58.8	58.5	59.2	60.4	61.3	62.1	63.1	63.5	63.8	63.2	62.0	60.8

TABLE E

DEPARTURES FROM AVERAGE OF MEAN MINIMUM TEMPERATURE

Station: Pepeekeo

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	+ .3	+ .4	+ .3	— .5	0	+ .2	+1.2	+1.8	+1.1	+ .8	+ .7	— .1
1906....	+ .5	+ .3	—1.5	+ .7	+ .7	+1.0	+ .2	+ .6	0	+ .5	+ .6	+1.7
1907....	+2.9	+1.7	+ .9	— .2	+1.7	....	+2.8	+1.8	+1.9	+1.5	+ .7	+1.5
1908....	— .4	— .2	+1.4	— .8	1.7	—3.4	—5.1	—5.8	—4.0	—3.6	—2.5	—2.0
1909....	— .4	+1.2	+ .8	+ .2	— .6	+ .4	— .3	—1.0	— .9	+ .5	+ .9	+ .4
1910....	— .4	—1.1	0	—1.0	— .1	— .4	— .7	+ .1	— .3	— .7	+ .2	— .4
1911....	— .6	+ .8	— .7	+1.0	+ .1	+ .5	+ .3	+ .4	— .6	—1.0	— .5	— .9
1912....	—1.2	0	—2.0	— .6	—1.3	— .7	— .4	— .2	— .4	+ .2	— .1	— .1
1913....	+ .5	— .3	— .6	—1.4	—1.5	— .7	— .9	+ .8	+ .1	+1.1	+ .7	0
1914....	—1.5	— .3	0	+ .8	+ .5	+1.4	+2.0	+1.9	+1.9	+ .4	+ .5	— .9
1915....	— .7	—1.4	— .2	0	+1.9	+1.8	+ .8	+ .9	+ .9	+ .5	0	+ .6
1916....	+ .9	+ .6	+1.7	+ .5	—1.1	— .9	....	—2.6	....	—1.8	—1.7	— .5
1917....	—1.1	—1.4	— .5	—1.3	—1.7	—2.4	—1.1	— .4	— .7	—1.7	— .8	— .4
1918....	— .7	—2.2	—1.7	—1.0	— .9	— .2	— .6	—1.4	+1.3	+1.1	+ .7	— .6
1919....	— .3	+1.7	— .5	+ .4	— .6	+ .1	— .3	— .2	— .3	+ .6	— .1	0
1920....	+1.2	+1.3	+ .1	+ .6	+1.3	— .5	—2.6	—1.4	—1.0	—1.4	—2.0	—1.3
1921....	— .1	+2.2	+1.9	+ .6	+ .4	+ .6	+ .1	—1.7	—1.5	+ .1	+ .5	— .7
1922....	+ .3	+ .1	+ .4	+ .8	— .7	—1.6	— .8	— .8	—1.8	+ .3	—1.6	—1.0
1923....	—1.6	—3.5	—1.5	— .8	+ .7	+ .5	+ .7	+ .9	+1.3	+1.5	+ .8	+1.3
1924....	—1.1	+1.7	0	+1.5	+ .5	+ .3	— .3	+ .2	— .3	+ .2	+ .5	+ .9
1925....	+ .3	+ .3	— .1	— .6	+ .6	+ .2	+ .7	+ .4	+ .5	+ .5	— .5	+ .5
1926....	+ .4	—3.1	—3.0	—1.7	— .4	+ .9	+ .5	+1.0	+1.0	+1.3	+ .5	+1.3
1927....	+1.2	+ .9	+1.9	+1.5	+ .9	+1.9	+ .9	+ .2	— .4	— .2	+ .6	+ .6
1928....	0	—1.1	— .2	+ .4	— .1	— .6	+ .6	+2.1	+ .3	— .7	+ .3	— .7
1929....	+ .9	+ .4	+1.2	+ .6	+1.2	+1.5	+1.2	+ .5	+ .4	+ .2	+ .4	+ .3
1930....	+ .7	+1.6	+1.0	— .1	— .5	+ .3	+ .4	+1.3	+2.2	+ .9	+2.3	+1.7
Means..	63.2	63.1	63.5	64.8	65.8	66.5	67.8	68.4	68.4	67.4	66.3	64.7

Station: Eleeie

1917....	0	— .2	+2.0	+1.3	+ .6	+ .3	— .9	— .8	....	—2.2	—2.1	—1.3
1918....	— .4	— .3	—1.8	—2.0	—2.3	—1.8	...	—1.4	—1.1	+ .1	—1.1	— .8
1919....	—2.8	— .3	—1.7	—1.3	—2.8	— .5	—1.5	—1.5	—2.8	—1.8	—1.3	—1.5
1920....	—2.2	—1.9	—1.9	—1.5	—2.1	—1.2	—2.0	—1.0	—1.9	— .6	+1.3	— .4
1921....	+1.0	— .1	—2.0	— .4	—2.3	—1.0	—2.1	—2.7	—2.1	—2.7	—2.3	— .9
1922....	— .8	—1.4	—1.6	—1.4	—3.5	—2.7	—2.4	—2.0	—1.7	—1.8	—3.0	—2.3
1923....	+ .4	—3.5	—2.1	—1.9	—2.0	—3.0	—2.2	—2.3	—2.1	—1.1	—1.6	—1.4
1924....	—2.5	—1.2	—2.7	—2.1	—3.0	—2.2	—1.7	....	— .6	— .9	—1.3	— .4
1925....	+ .7	+1.2	—2.9	+ .7	+2.0	+3.5	+3.9	+1.4	+2.2	+2.2	+3.1	+4.6
1926....	+4.3	+4.3	+4.5	+1.0	+ .8	+3.8	+4.8	+4.6	+4.4	+2.5	+4.1	....
1927....	....	....	+4.0	+1.1	+1.5	+1.5	+ .9	+1.4	+1.2	+2.4	+2.7	+3.0
1928....	+3.2	+ .2	+3.0	+3.2	+ .6	+ .2	+1.1	+ .5	+ .7	+1.7	+ .8	+1.4
1929....	— .9	+ .5	+2.0	+2.3	+1.2	+1.7	+2.0	+1.9	+1.8	+1.8	— .6	— .6
1930....	— .2	+2.2	+1.0	+ .6	+ .8	+1.2	+ .5	+2.2	+1.8	+ .5	+ .7	+1.0
Means..	62.0	62.3	62.7	64.2	66.9	68.5	69.8	70.0	69.8	68.6	66.7	64.0

TABLE E

DEPARTURES FROM AVERAGE OF MEAN MINIMUM TEMPERATURE

Station: Kealia

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	-3.0	-2.4	-.6	+.4	+.3	+.1	+.8	+1.2	+.7	+.9	+1.5	+1.2
1906....	+.1	-1.2	-1.0	+.8	-.1	+1.3	+1.5	+.8	+.1	+1.5	+.5	-.2
1907....	+1.7	....	+.4	-1.5	-1.8	0	-.6	-.1	....	-1.0	-.8	+.4
1908....	....	....	-.9	-1.2	+2.2	+.9	+.8	+.2	+1.0	+.2	-1.8	+3.5
1909....	-1.4	+.6	+.4	-1.6	0	-.8	-.9	-1.2	-.9	-1.1	-2.3	-.8
1910....	+.5	-.7	-.3	+.5	-2.6	-2.5	-2.1	-1.7	-1.7	-1.8	-1.0	-2.1
1911....	+1.3	....	-1.5	-.3	+.6	+.5	-.7	+1.5	0	-1.2	+.9	+1.5
1912....	-.7	-1.0	-.3	+.9	+.1	-.9	-1.2	-1.8	-.4	+2.2	....	+3.0
1913....	-1.0	-2.6	-1.5	-.3	-1.9	-1.3	-1.1	-.8	-.8	-1.2	+.5	-1.9
1914....	-2.6	....	-4.2	-3.1	-2.0	-1.6	-1.2	-.5	+.2	+.2	-3.0	-5.7
1915....	-4.9	-2.1	-6.2	-4.4	-3.9	-3.4	-2.5	-3.7	-4.4	-3.0	-2.3	-3.9
1916....	-5.3	-3.1	-4.6	-5.7	-5.8	-6.6	-7.3	-8.8	-7.3	-6.5	-4.6	-5.9
1917....	-6.2	-2.9	+1.5	+1.5	+.4	+1.6	-.8	-.2	-.4	-.7	+.8	+.7
1918....	+.8	+2.9	+1.0	-1.6	+.4	+.2	+.7	+.6	+.6	+2.2	-.3	+2.4
1919....	+.5	-1.7	+1.3	+1.9	+1.5	+1.7	+1.3	+.8	-.2	+2.1	+2.3	-2.0
1920....	+1.6	+.9	....	-.1	-1.8	+.9	+.8	+1.3	+1.7	+1.1	+1.2	+2.3
1921....	+4.5	+1.4	-.3	+2.5	-1.0	+1.1	+1.5	-.1	+1.0	-1.5	+.5	+1.7
1922....	+2.2	+2.5	+1.6	+1.3	+.9	-.3	+.8	+1.3	+.8	+.3	+.7	-.9
1923....	+3.8	-1.5	-.2	+.8	+1.6	+.4	+2.0	+.4	+1.9	+1.8	+1.0	+1.8
1924....	-1.0	+1.8	+1.0	-.2	-.2	+.9	+1.5	+1.0	+.7	+1.7	-.1	-1.3
1925....	+2.8	+2.4	+2.0	+2.3	+1.6	+1.7	0	+1.3	-.2	-1.0	+2.3	+.2
1926....	+1.1	+1.7	+2.1	-1.4	+2.3	-.6	+2.3	+1.8	+2.1	0	+.7	+3.4
1927....	+3.7	-.3	+3.2	+1.3	+2.6	+1.6	+1.5	+1.1	+.5	+2.7	+3.0	+1.7
1928....	+3.9	+1.1	+2.1	+2.9	+1.4	+1.5	+1.0	+1.2	+1.9	+1.7	0	+2.2
1929....	-.2	+2.3	+3.3	+3.2	+1.8	+1.4	+1.9	+1.7	+2.1	+.9	-1.1	-1.9
1930....	-1.8	+2.7	+.4	+1.1	+2.9	+1.4	+1.8	+3.4	+2.0	+.5	+.8	+1.8
Means..	62.5	62.1	63.8	65.9	67.9	70.2	71.4	72.0	71.5	70.0	67.4	65.1

Station: Kilauea

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	-3.3	-3.1	-2.0	+.6	-.3	-.9	-.7	+.2	0	-.2	+.5	+.1
1906....	-.7	-2.3	-3.0	+.7	-.2	+.2	0	-.3	+.2	+1.0	+.4	+.7
1907....	+.6	+.9	-.1	-1.8	-.8	0	-.4	-.2	-.3	-1.3	-1.0	-.1
1908....	-1.3	-.2	+.4	-.5	-1.4	-1.2	-.4	-1.3	-.3	1.1	-1.9	+1.1
1909....	+.5	-.4	+.3	-.9	-.2	+.8	0	-.8	-.8	+.9	-2.5	+.4
1910....	+.7	+.6	+.7	+.8	-1.0	-1.1	-.9	-.5	-.8	-1.5	+.5	-.6
1911....	+1.4	+.3	0	+.6	+.4	+.6	-.1	+.8	-.1	-1.0	+.2	+.5
1912....	+.1	+.7	-.9	-.3	-.6	-.6	-.5	-.7	0	+1.2	-.3	+2.0
1913....	-.1	-.3	-.9	+.7	0	+.2	+.8	+.6	+.3	-.2	+1.8	-1.7
1914....	-.4	-1.4	-2.1	-1.4	-.1	+.5	+.8	+1.5	+1.3	+.6	-.5	-3.8
1915....	-3.5	-.3	-1.8	-1.2	+.9	+1.2	+.9	+.6	+.4	+1.1	+1.6	+1.6
1916....	-.1	+1.3	+1.0	+1.7	+1.5	+.2	-.1	-2.1	-.8	-.3	+1.1	+.8
1917....	+.8	-3.0	+1.6	+.7	+.6	+.5	-.4	-.9	-.6	-1.2	+.8	+1.9
1918....	0	+1.1	-1.2	-.2	0	-.2	+.5	+.3	-.2	+1.9	0	+1.0
1919....	-.6	+1.5	+.9	-.2	-.4	+.7	+.5	-.2	-1.5	+.4	+.3	-1.5
1920....	+.6	+.8	+.5	+.1	+.5	+.5	+.9	+1.3	+.3	+.3	-.1	+.7
1921....	+2.8	+1.3	-.1	+1.5	+.1	+1.3	+1.6	+2.7	+.7	-1.0	+.1	+.7
1922....	-1.6	+.7	+1.0	+.6	0	-.1	+.1	-.8	+.4	+.2	+.5	-1.5
1923....	+1.8	-1.6	+.1	+.1	+.9	-.4	+.9	-.3	+1.3	+.2	-.5	+2.1
1924....	-1.0	+.3	0	-1.1	-1.4	-.2	-.5	-.4	-1.1	+.1	-.4	-1.9
1925....	+1.9	+2.4	+.8	+.8	+.4	-.6	-2.0	-.5	-1.5	-1.0	+.2	-1.3
1926....	-2.2	+.1	+.3	-2.8	-.4	-2.8	-1.4	-.1	+.8	-1.0	-1.2	+.3
1927....	+1.9	-.7	+2.3	-.1	+.8	+.9	0	-.3	-.6	+1.2	+1.9	+.2
1928....	+.8	-.5	+.3	+.8	-.2	-.9	-.9	-.6	0	+.1	-.3	-.1
1929....	-1.2	+.2	+1.5	+.8	+.7	+.2	+.2	-.2	+.7	+.3	-1.7	-1.8
1930....	-1.4	+1.2	-.1	-.2	+1.0	+.7	+.5	+1.3	+1.3	+.1	+.5	....
Means..	61.7	61.5	62.5	64.4	65.7	68.0	69.0	69.9	69.2	68.0	65.9	63.8

TABLE E
DEPARTURES FROM AVERAGE OF MEAN MINIMUM TEMPERATURE

Station: Koloa

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	-4.7	-2.3	-5.8	-8.1	-5.5	-.9	-.7	0	+.2	+.2	+.3	+1.2
1906....	-1.2	-1.6	-3.9	+.2	+.2	+1.5	+.4	-.1	+.1	+.9	+.4	+.1
1907....	+1.1	+1.2	0	-2.4	-1.5	-.3	-1.5	-.7	-.1	-1.0	-1.5	-.2
1908....	-.6	-.1	-.3	-.3	+1.0	-.5	-.4	-1.1	0	-.5	-1.9	+1.1
1909....	-.1	+.1	+.4	-1.6	-.4	-.3	-.8	-1.9	-1.2	-1.9	-2.5	-.7
1910....	+1.7	+.1	+1.5	+.9	-1.4	-1.3	-.7	-.7	-.3	-1.3	+.8	-1.9
1911....	+1.0	-.1	-.6	+.9	0	-.2	-.7	+.3	-.5	-2.0	+1.0	+.1
1912....	-.5	-1.4	-.8	+.2	+.2	-1.1	-.1	-.2	-.1	+1.8	+.4	+2.8
1913....	-.1	-1.4	-.4	+1.4	-.2	+.2	+.7	+1.0	+.1	-.2	+2.5	-2.2
1914....	-1.6	-2.2	-3.3	-1.2	-.8	+.8	+1.0	+1.0	+1.9	+1.4	-.1	-3.6
1915....	-1.6	+.1	-1.9	-1.1	+.2	-.3	+.6	+.3	-.2	+.6	+2.3	+1.5
1916....	+.7	+1.8	+1.7	+2.2	+.8	-.3	-.2	-2.0	-.9	-1.3	+.1	+.2
1917....	-1.3	-3.2	+2.3	+1.7	+.4	+1.1	-.4	-.2	-.4	-1.3	+.2	-1.0
1918....	+.8	+.8	+.5	-.3	-.1	-.1	+.5	+.5	+.5	+1.7	+1.0	+2.2
1919....	-.7	+1.9	-.3	+.6	+.8	+.7	+.3	+.4	-1.6	+.8	0	-2.3
1920....	-1.5	+.8	+.4	+.3	+.1	+1.2	+.8	0	-.2	+.7	+.4	+1.9
1921....	+3.6	+2.3	+.6	+2.1	-.3	+1.2	+.6	-.6	+.1	-1.5	-.6	+.6
1922....	+1.8	+1.2	+.8	+.8	-.3	-1.3	-.7	-1.0	-.8	-.6	-1.5	-2.3
1923....	+1.8	-2.5	+.1	+1.2	+.9	+.3	+.2	+.4	+1.2	+1.2	+.5	+1.0
1924....	-2.3	+1.0	+.8	0	-.4	+.1	-.2	-.2	+.8	+1.0	-.5	-.9
1925....	+2.2	+1.0	+.4	+.5	+.4	+.5	-.6	+.5	-.4	-1.3	+1.7	+.2
1926....	+.5	+.2	-.1	-3.0	+1.2	-1.8	+1.0	+.4	+.5	-.4	-.7	+1.0
1927....	+2.5	-1.3	+2.1	+.5	+1.1	0	-.2	-.4	-1.2	+.7	+1.7	+1.0
1928....	+2.2	-.1	+1.6	+1.9	+.5	-.2	-.3	0	-.1	+.6	-.6	+1.9
1929....	-1.0	+1.6	+2.7	+1.7	+1.1	+1.1	+1.5	+.6	+.7	+.9	-1.6	-2.3
1930....	-2.6	+1.8	+2.0	-.5	+1.4	+.4	+.9	+2.0	+1.7	+.7	-1.6	+1.4
Means..	61.7	61.7	62.8	64.8	66.8	69.1	70.2	70.9	70.4	68.8	66.3	64.2

Station: Lihue

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	-5.0	-2.1	-1.5	-.2	-.2	-.1	-.1	+.7	+.1	+.7	+1.0	+.3
1906....	-.9	-2.5	-4.8	+.2	-.1	+.8	-.5	-.2	-.1	+.7	+.5	+1.1
1907....	+1.0	+2.1	-.3	-3.4	-2.1	-.5	-1.0	-.1	-.5	-.9	-2.5	-.9
1908....	3.1	-2.0	+1.1	+.3	+1.3	0	-.2	-.7	0	-.9	-3.7	+1.1
1909....	-.8	-.5	+.1	-3.8	-1.7	-2.0	-6.2	-5.5	-2.7	-1.3	-2.6	-.1
1910....	-.2	-1.2	-.1	-.4	-2.8	-2.8	-2.2	-1.8	-1.8	-1.7	+.9	-3.6
1911....	+1.7	+.5	-.8	+.2	-.7	+.4	-.7	+1.0	+.4	-1.0	+.6	+.7
1912....	-.6	+.1	+.3	+1.4	+.1	-.4	+.5	-.2	+.3	-1.7	-2.9	+3.1
1913....	-.4	-.9	-.4	+1.0	-.2	+.9	+1.0	+1.0	0	-.4	+2.3	-2.4
1914....	-.3	-2.2	-2.5	-1.7	-.9	+.1	+.4	+.4	+.8	+.5	-1.1	-4.0
1915....	-1.9	0	-3.9	-1.1	-.4	-1.8	0	-.5	-1.1	-.5	+1.4	-.9
1916....	....	-.8	+2.0	+1.2	+1.5	+.4	0	-1.6	+.2	+.9	+2.3	+1.7
1917....	-.1	-3.0	+1.2	+.5	-.6	+1.6	-.1	+.5	-1.2	-1.6	+.8	-1.0
1918....	+.9	+1.7	0	-1.2	-.2	-.3	+.8	+.4	-.3	+2.3	+.4	+1.4
1919....	-.8	+2.2	-.1	+1.0	-.1	+.8	+.5	+.3	-.8	+.8	+.2	-2.8
1920....	-.8	+.6	0	-.6	-.6	+.4	+.3	+1.0	+.7	+1.0	-.3	+1.7
1921....	+3.8	+2.7	-.3	+1.8	-.4	+1.3	+1.4	-.5	+.2	-1.5	-.7	+1.1
1922....	+1.6	+2.0	+.1	+.6	-.2	-1.0	-.4	-.4	+.3	-.2	-.4	-2.0
1923....	+3.1	-2.9	-.9	+.4	+.4	-.3	+.8	-.2	+1.0	+1.6	+.3	+1.4
1924....	-2.9	+.6	-.5	-1.1	-.9	-1.0	-.3	-.1	+.4	+1.3	-.7	-.3
1925....	+1.6	+1.5	+.5	+1.1	+.9	+1.0	-.5	+.7	-.7	-1.5	+2.6	+.4
1926....	+.6	+1.0	+1.4	-2.2	+1.6	-1.0	+1.1	+1.1	+.1	-.5	-.1	+2.2
1927....	+3.2	-.2	+2.9	+.3	+2.3	+.5	+1.2	+.9	-.4	+2.4	+2.9	+.7
1928....	+3.2	0	+1.7	+2.8	+1.0	+.5	+1.4	+.9	+.9	+1.6	+.3	+1.9
1929....	-.5	+2.2	+2.7	+1.9	+.9	+1.2	+1.6	+1.4	+.5	+.5	-1.7	-2.7
1930....	-2.8	+2.1	+.9	-.2	+2.4	+1.4	+1.3	+2.7	+1.5	+.5	+.3	+.9
Means..	60.6	60.1	62.0	64.0	66.1	68.4	69.5	70.1	69.6	67.5	65.0	63.1

TABLE E
DEPARTURES FROM AVERAGE OF MEAN MINIMUM TEMPERATURE

Station: Makaweli

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	-4.7	-1.5	-2.3	-1.0	-.3	-.3	-.6	+1.0	+ .5	+ .1	+1.4	-.5
1906....	+ .5	+ .1	-2.6	+1.0	+1.4	+2.3	+ .3	+1.7	+1.3	+2.3	+ .9	+1.4
1907....	+2.7	+2.2	+ .9	-1.6	-.7	+ .3	-.3	+1.2	+1.0	-.1	0	+ .5
1908....	+1.9	+1.5	+1.6	+ .6	+1.1	-.1	-1.1	-.6	-.3	-.3	-2.2	0
1909....	+ .4	+1.8	+1.3	+ .4	-.3	+ .3	-.5	-1.0	-1.1	+ .1	0	+ .1
1910....	+ .3	-1.7	+ .7	+1.1	-1.3	-1.1	-1.1	-.5	+ .5	-.1	+ .7	-1.1
1911....	+1.2	-.2	+ .2	+ .9	-1.1	-.7	-2.4	+ .7	-.2	-.7	+1.5	+ .6
1912....	+2.0	-.2	-.8	+ .3	+1.0	-1.1	-.7	-3.5	-4.9	-4.4	-.5	+2.8
1913....	+1.7	-.2	-.3	+1.6	+ .4	+ .6	+ .8	+1.1	+1.4	+1.6	+2.6	-.5
1914....	-1.7	-.6	-.9	+ .2	-.5	+ .8	+1.5	+2.1	+1.5	+ .6	+ .4	-3.1
1915....	-1.7	-1.9	-.2	+ .2	+ .8	+1.1	+1.5	+1.7	+1.3	+1.7	+1.7	+1.0
1916....	+1.1	+1.9	+1.1	+1.5	+ .9	+ .4	0	-1.9	-.2	+ .5	+ .8	+ .7
1917....	+ .4	-.6	+2.7	-.2	-.2	+1.9	-.3	0	+1.0	+ .3	+ .3	+ .4
1918....	+ .5	+1.5	-.1	0	+ .1	+ .4	+ .8	+ .9	+1.4	+2.4	-.2	+ .7
1919....	-1.3	+1.5	+ .5	+ .9	+ .1	+ .4	-1.1	+ .7	-.7	+ .5	+ .6	-.8
1920....	-.6	0	-.5	-1.0	+ .4	+1.0	+ .7	+1.0	0	+ .2	-.7	+1.1
1921....	+2.4	+1.8	+ .1	+1.2	+ .2	+1.1	+ .6	-1.4	-.2	-1.9	-1.8	-1.0
1922....	-.1	-.9	-.6	-.3	-2.1	-1.2	-1.1	-.9	-.8	-1.5	-3.2	-2.8
1923....	+ .4	-2.5	-.7	-.1	+1.4	-.7	+ .8	-2.8	-.2	+1.9	+ .7	+ .3
1924....	-1.0	+1.0	0	+ .4	-.1	-1.1	+1.0	+1.1	+1.3	+ .3	+ .1	-.1
1925....	+1.3	+1.1	+ .3	+ .5	-.5	+ .7	+ .9	+1.4	-.9	-.5	+ .9	+1.0
1926....	+ .3	-.1	+ .5	-2.5	+1.1	-.7	+ .2	+ .6	+ .2	-.4	-1.0	+3.9
1927....	+1.0	-1.5	+ .9	-.8	+ .9	-.5	-.1	-1.4	-.3	+ .6	+ .8	-.2
1928....	+ .2	-2.1	+ .5	+ .4	-1.3	-1.4	-.7	-1.0	-.9	-.1	-.6	-.8
1929....	-2.8	-1.3	+ .1	-.2	-1.4	-.5	0	0	+ .3	-.6	-2.4	-3.7
1930....	-3.6	+ .1	-1.9	-3.0	-.8	-1.5	-1.1	+ .5	-.3	-1.8	-1.1	....
Means..	62.3	62.4	63.1	64.4	66.4	68.4	69.6	70.0	69.7	68.4	66.4	64.3

Station: Hana

1905....	....	....	....	....	....	....	....	....	....	....	....	....
1906....	....	....	....	....	....	....	....	....	....	....	....	....
1907....	....	....	....	....	0	+1.9	+ .8	-.7	+ .7	-.6	+ .3	+1.4
1908....	+1.2	+4.4	+3.5	+3.5	+2.2	+ .4	-.2	+ .7	+ .5	+ .3	-1.3	+1.1
1909....	+2.0	+ .8	+ .3	+ .6	0	+ .3	-.3	-1.2	-1.7	-.7	+1.2	+1.4
1910....	0	-2.1	+ .1	-.8	-1.6	-.9	-.8	-.8	-.7	-.7	+ .5	-1.4
1911....	-.3	+ .7	-1.2	+ .1	.1	+ .1	+ .3	-.4	-.9	-3.1	-.6	-.6
1912....	1.7	-.6	-1.8	0	-.2	+ .3	-.2	0	+2.8	+1.5	+1.5	+3.0
1913....	+3.3	+1.1	+1.6	+ .9	+ .5	+1.3	+1.3	+1.0	+ .2	+1.6	+1.3	+ .4
1914....	-.2	+1.0	0	+ .1	-.4	+ .1	+ .4	+ .7	+ .7	-.3	+1.4	+ .5
1915....	+ .8	-1.1	+3.9	+2.6	-4.6	+1.4	+2.1	+1.5	-.9	-1.2	-.9	-.5
1916....	+1.7	+ .3	+1.3	+ .1	-.4	-2.4	-.2	....	....	....	....	-.8
1917....	0	-2.5	+1.4	+ .9	+ .6	+1.0	-.6	-.3	-.5	+ .5	-.6	+ .3
1918....	+1.1	-.1	1.0	-.7	+ .4	-1.1	+ .5	+ .8	+1.2	+2.0	+1.6	+1.3
1919....	+ .5	+1.1	-.5	+1.0	-.1	+1.4	+ .2	+1.0	+ .1	+1.4	+1.2	+ .5
1920....	+1.0	+1.7	-.3	+ .2	+1.6	+1.5	+ .1	+1.1	+1.4	+.9	+ .3	+ .9
1921....	+2.0	+3.9	+ .1	-2.7	-4.6	-3.1	-4.2	-4.3	-5.1	-4.7	-4.7	-2.5
1922....	-4.0	-5.2	-4.7	-4.1	-6.0	-4.6	-2.8	-4.6	-4.9	-1.2	-4.9	-3.4
1923....	-2.7	-4.3	-4.0	-4.0	-3.0	-4.0	-4.3	-3.3	-3.3	-4.3	-4.2	-3.9
1924....	-5.7	-3.2	-7.6	-.8	-2.3	-2.3	-.8	-.3	-.3	-.1	-.9	-2.1
1925....	-.7	-.3	-1.8	-1.6	-2.2	....	....	....	+1.6	+1.9	+1.8	....
1926....	....	....	+3.6	+ .2	+4.0	+2.7	+3.2	+3.9	+4.0	+2.9	+3.4	+2.9
1927....	+2.1	+1.0	+2.5	+ .3	+2.0	+1.7	+1.9	+ .6	+ .7	+ .7	+2.2	+ .9
1928....	+1.4	-.5	+1.3	+2.0	+1.3	+1.1	+ .7	+1.1	+ .9	+1.0	+1.0	-.4
1929....	-.6	+ .7	+2.8	+1.9	+1.5	+1.5	+1.8	+ .6	+1.6	+1.2	-.5	-.6
1930....	-.5	+2.5	+ .8	+ .1	+1.1	+1.0	+1.3	+3.2	+3.2	+1.6	+1.2	+1.6
Means..	64.5	64.5	64.9	66.3	67.5	68.6	69.6	70.1	70.2	69.5	67.9	66.4

TABLE E

DEPARTURES FROM AVERAGE OF MEAN MINIMUM TEMPERATURE

Station: Kaanapali

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	-2.8	-1.2	-.7	0	+.3	-1.8	-6.9	-6.1	+1.3	+1.0	+1.3	-.1
1906....	+.2	-2.4	-2.4	+.2	+.7	+1.2	+2.0	+1.6	+1.0	+1.6	+.2	-.2
1907....	+2.0	+1.6	0	-1.7	-1.1	+.3	+.6	+1.1	+1.6	-.5	+.3	-1.7
1908....	-1.1	+.3	+.2	-.4	-1.0	-2.6	-1.5	-1.8	-.6	-1.7	-2.4	-.4
1909....	-2.4	+.7	+1.7	+.5	+.6	+.7	+.4	0	-.2	+.1	-.1	-.2
1910....	0	-.4	+.2	+.1	-1.3	-1.4	-1.0	0	-.3	+.3	+.4	-.3
1911....	+.3	+.6	-.1	+.5	-.3	+.2	+1.7	+1.8	+2.1	-.7	+.8	+1.2
1912....	-.4	+1.1	-.7	+.1	-.8	-1.8	-.1	+.9	+.6	+1.8	+.7	+1.7
1913....	+.8	+1.0	+1.0	+2.3	-1.2	-.6	+.7	+1.9	+.8	+1.3	+2.9	+.3
1914....	0	+.6	-.2	0	+.2	-.1	+1.8	+2.2	+2.1	+.4	+1.1	+.3
1915....	+.4	-.1	-1.0	0	+.9	...	...	...	...	...	...	+.4
1916....	+1.5	+.9	+1.5	+1.1	+.3	-.3	-.2	-1.1	-.8	-.1	+.8	+.9
1917....	+.3	-.1	+.9	+.5	-.6	+.6	+.8	+.1	+.6	+.3	+1.5	+2.7
1918....	+2.2	+1.3	-.2	0	-1.0	-.1	+2.4	+1.2	+.7	+2.1	+1.7	+.9
1919....	-.1	+.7	+1.3	+1.4	+.6	+1.2	+2.3	+2.7	+1.6	+1.7	+.9	+1.2
1920....	+1.4	+1.4	+.9	+.9	+.5	+.8	+1.0	+1.8	+1.2	+.5	+.8	+1.7
1921....	+4.2	+1.3	+.8	+2.0	+.8	+2.7	...	+1.3	+1.3	+1.4	+1.0	+2.2
1922....	+1.6	+1.9	+.2	+.4	-1.2	-1.0	-.2	-.1	-.4	+.7	+.7	-.2
1923....	+3.6	+1.2	+1.6	+.9	+.3	-.3	+1.1	+.4	+.8	+2.0	+1.5	+1.6
1924....	-1.5	+1.1	-.5	+1.3	-.8	-.8	+.9	+.5	+.7	+1.0	-.6	+.2
1925....	+1.0	+.4	+1.4	+.4	-.4	-.4	+.7	+1.3	+.1	+.2	+.9	0
1926....	-.7	0	+1.4	+.4	+4.5	+1.8	+2.0	+1.3	-1.1	+.2	+1.0	+.2
1927....	+1.7	+1.0	+1.5	+3.7	+5.4	+4.7	+2.0	+1.7	+1.5	+3.0	...	+4.6
1928....	+.3	-1.4	-1.5	-3.5	...	...	...	-1.9	-4.8	-5.9	-3.8	-4.5
1929....	-5.1	-6.4	...	-4.0	+1.4	+1.9	-6.2	-6.3	-6.4	-4.3	-6.2	-7.0
1930....	-7.7	-5.4	-6.3	-6.7	-7.6	-5.8	-3.7	-4.5	-4.3	-5.5	-4.6	-6.1
Means..	62.2	61.5	63.0	64.4	66.6	68.2	68.5	69.0	68.8	67.5	65.7	63.7

Station: Wailuku

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	-4.9	-2.6	-1.7	-.6	-.7	-1.0	-.3	+.4	-1.2	-.8	-.5	-1.1
1906....	-1.1	-1.5	-4.5	-.2	-.3	+.9	+.1	+.1	-.2	+.6	-.8	-.2
1907....	+.5	+1.1	-.8	-2.7	-1.3	+.2	+.2	+.5	+.2	-.1	-.2	+.8
1908....	-.4	+1.1	+1.3	+.2	+.8	-.8	-.9	-.8	-.9	-.3	-1.4	+.2
1909....	-.1	-.5	0	-1.7	0	0	-1.2	-2.1	-1.7	-.6	-1.6	-1.0
1910....	-.2	-2.0	+.8	-.2	-1.6	-1.2	-1.4	-1.8	-2.1	-2.2	-.7	-2.2
1911....	-.4	-.7	-1.6	+.1	-.8	-.9	-1.1	-.6	-1.2	-2.2	-.3	+.2
1912....	-1.7	-.3	-1.3	-.5	0	-1.0	-.3	-.8	-.7	+1.5	+.2	+1.3
1913....	+.7	-1.1	+.4	+.1	-1.0	-.6	0	+.1	-1.1	-.2	+1.4	-.9
1914....	-1.4	-1.0	-1.6	0	-.6	+.5	+.3	+.3	+.7	-.3	+.1	-2.1
1915....	-.5	-.9	-1.6	-1.6	+.3	0	-.7	-.5	-.8	-.1	+.7	-1.3
1916....	-1.5	-1.3	+1.5	0	-.5	-1.1	-2.0	-1.2	-.9	-.5	+1.3	+.8
1917....	-.4	-1.2	+1.1	+.6	0	+.9	0	-.1	-.4	-.8	+.6	+.5
1918....	+.8	+.1	+.1	0	+.1	-.8	+1.3	0	+.1	+1.6	+1.0	+1.5
1919....	+.4	+1.6	+.2	+1.1	-.1	+.9	+.4	+.5	-1.9	-1.1	-2.2	-2.1
1920....	-2.3	-1.0	-.8	-.1	-.4	-.7	+.4	+.6	+.8	+.6	+.2	+1.4
1921....	+3.1	+.9	-.2	+.5	-.8	+1.8	+.5	-.1	-.2	-.7	-.6	+.5
1922....	+1.5	+1.2	+.2	+.2	-.1	-.1	+.3	-.1	-.6	-.6	-1.5	-.7
1923....	+2.6	-.7	+.2	+.3	+.7	+.1	+.4	-1.0	-.1	+1.6	0	-.2
1924....	-2.5	+2.1	+.3	+.5	-.4	+.3	+.2	-.7	-.8	-1.2	-2.0	-1.3
1925....	+1.3	+.2	-.3	-.4	+.2	+.3	+.3	+1.3	+1.1	+.9	+2.4	-.3
1926....	+1.8	+1.5	+1.1	-.4	+1.7	0	+1.0	+1.7	+1.4	+.2	+1.0	+1.6
1927....	+2.1	+1.6	+3.0	+1.2	+2.0	+.9	+.9	+.6	+.1	+1.1	+1.5	+1.6
1928....	+1.8	-.2	+.9	+1.4	+.3	0	+.8	+.9	+6.0	+1.1	+.9	+1.2
1929....	+1.4	+1.8	+1.5	+1.5	+1.2	+1.8	+2.4	+1.7	+1.5	+1.6	-.2	+.5
1930....	-.5	+1.8	+1.1	-.2	+1.2	+.4	-.2	+2.3	+2.2	+.8	+1.6	+1.1
Means..	63.0	62.6	63.7	65.5	67.3	69.1	70.5	71.2	71.0	69.3	67.0	65.2

TABLE E

DEPARTURES FROM AVERAGE OF MEAN MINIMUM TEMPERATURE

Station: Ewa Mill

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	-5.0	-3.1	-3.0	-.7	+1.0	-.2	+.9	+1.8	+1.3	+.5	+1.3	-1.1
1906....	+.1	-.5	-2.6	+1.4	-.1	+2.7	+1.5	+1.9	+1.3	+2.2	+.8	+2.0
1907....	+3.6	+1.8	+1.4	-1.7	+.4	+1.3	+.6	+2.6	+2.2	+1.1	+1.7	+1.1
1908....	+.2	+1.4	+2.3	+.4	+1.3	-.3	-.9	-.7	-1.0	-.8	-2.0	+.3
1909....	-.8	+.9	+2.0	-.4	+.7	+2.1	+1.6	-.4	-.3	+.6	-.5	+.7
1910....	+1.3	-.3	+1.5	+.7	-.1	+.8	-.6	-.7	-.5	0	+1.3	+.9
1911....	+1.7	+1.2	+.8	+1.9	+1.5	+1.7	+2.0	+2.1	+2.0	-.4	+.6	+1.4
1912....	+.5	+1.6	-.9	+1.3	+.9	+.4	+.6	+.9	+1.3	+2.5	+.9	+3.3
1913....	+1.5	-.5	+1.1	+2.0	+.9	+1.0	+.4	....	+1.1	+1.6	+2.4	-.9
1914....	-.3	-.6	-.3	+.3	+1.0	+1.5	+2.2	+2.9	+3.6	+1.6	+1.4	-1.1
1915....	-.2	+.7	-.3	-.5	+1.3	+2.0	+1.9	+2.5	+1.8	+2.2	+2.6	+2.2
1916....	+1.7	+1.9	+2.6	+1.8	+2.0	+.9	+.1	-1.3	-.2	+.9	+2.0	+.6
1917....	-.5	-.2	+1.8	+.4	-.3	0	-.7	-.6	-.6	-.6	+.7	+.4
1918....	+.6	+1.5	-.3	+.5	-.9	+.1	+1.6	+.6	-.4	+1.7	-.4	+.9
1919....	-1.7	+.9	-.8	0	-.2	+.1	+.5	+.6	-1.2	-.4	-1.1	-1.8
1920....	-1.2	-.8	+.1	-.6	-1.2	-2.6	+.5	0	+.1	+.1	-1.1	+.1
1921....	+2.2	-.5	-.5	-.2	-1.9	+.9	-.6	-1.1	-.6	-2.0	-1.3	+.2
1922....	+.2	+.5	-.4	-.1	-1.6	-2.4	-2.4	-2.3	-1.9	-1.8	-2.1	-3.5
1923....	+1.6	-3.6	-1.2	-1.1	-1.4	-2.6	-1.3	-2.1	-1.6	-2.1	-1.7	-1.3
1924....	-5.7	-1.7	-2.9	-2.6	-2.2	-3.8	-2.8	-3.6	-3.7	-2.2	-3.0	-3.3
1925....	+1.2	-1.1	-2.1	-1.6	-2.5	-2.6	-3.0	-3.1	-4.1	-3.9	-2.1	-.5
1926....	+.1	+.8	-.3	-2.3	+1.6	+.6	+.1	+.4	+.5	+.4	-.9	+1.4
1927....	+1.3	+.5	+2.7	+.8	+1.3	+.8	-1.9	-.7	-.6	-.7	+1.4	+.6
1928....	+.8	+1.7	-.6	+.3	-.2	-1.3	-.3	-.6	-1.3	-.9	-.5	+.1
1929....	-1.7	+.4	+.5	+.6	-.5	-.2	-1.4	-.6	+.2	+1.0	+.5	-1.0
1930....	-1.6	0	+.4	-1.2	-.1	-.3	+.6	+1.6	+1.4	-.2	-.8	....
Means..	60.9	60.4	61.6	63.3	64.7	66.5	67.9	68.6	67.9	66.5	64.5	62.8

Station: Kahuku

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	-1.5	-2.5	-.6	-.1	+.1	+.1	+.3	-.6	-.4	-.5	+.4	+.6
1906....	+.6	-.4	-2.6	+1.2	-.5	+1.3	+1.2	+.3	-.2	+1.1	+.5	-.4
1907....	+1.2	+2.2	-.3	-2.0	+.1	-.2	-.5	-1.1	-.1	-.1	-.7	-.1
1908....	-.2	0	-.4	-1.1	-.3	-1.5	-2.2	-2.2	-1.9	-1.7	-2.7	+.9
1909....	-1.9	-1.5	-2.7	-3.6	-1.8	-2.8	-3.2	-3.1	-3.0	-3.1	-3.5	-3.7
1910....	-1.1	-.7	+1.7	+.8	-1.0	-.5	+.2	+.2	+.1	-.8	+1.2	-1.8
1911....	+.6	-.2	-.4	+.8	+.6	+.1	+.7	+.4	+.3	-1.7	+.4	+.5
1912....	-1.0	-.3	+.5	+.5	+.6	+.6	+.2	+.2	+.1	+2.7	+1.0	+3.1
1913....	+.3	0	+1.2	+1.2	+.5	+.5	+1.4	+1.4	+1.5	-.5	+2.1	-1.7
1914....	-1.2	-.4	-.9	-1.1	-.4	+.8	+1.1	+1.4	+1.0	+1.5	+2.8	+5.1
1915....	+6.2	....	....	+3.3	-1.6	+1.3	+.9	+2.2	+1.6	+2.5	+2.2	+2.7
1916....	+2.9	+5.3	+2.3	+4.6	+1.3	+.1	-.9	-.6	+.3	+.2	+1.4	+.3
1917....	-.9	-2.2	+1.1	+.6	+.3	+1.2	+.6	+.6	-.6	-1.5	+.4	-.9
1918....	+.6	+.9	+1.0	-.3	-.7	-.5	+1.6	+.7	+.2	+1.9	+.3	+1.6
1919....	+.7	+1.5	0	+.5	+.6	+1.7	+1.0	+.1	-1.8	+.7	-1.2	-3.5
1920....	-1.5	+.5	-1.3	-.4	-.9	+.9	-3.6	+.3	+1.3	+2.1	....	+4.3
1921....	-3.1	-2.2	+.8	+1.6	+.7	+2.4	+1.8	+2.0	+1.2	-1.2	+1.5	+.6
1922....	+.7	+1.6	0	+.8	+1.2	+.7	+.3	0	0	-.4	-1.2	+1.5
1923....	+1.0	-1.9	-1.8	-.8	-.7	-.9	-.5	-.2	+.6	-.3	-.2	-1.1
1924....	-2.6	-.2	-.5	-2.4	-1.3	-1.6	-1.6	-2.1	-.4	-1.6	-2.7	-2.3
1925....	+1.0	-.4	-1.1	-1.5	-1.0	-1.4	-1.6	-.9	-1.1	-1.6	-.1	-3.7
1926....	-1.5	-.4	+.2	-3.2	-.5	-2.5	-.1	-1.0	+.5	-1.3	-1.1	-2.4
1927....	+.1	-2.2	-.3	-2.0	-.6	-2.2	-1.4	-1.5	-1.4	-.1	+1.8	+.8
1928....	+2.8	+.1	+1.4	+1.8	+1.9	+1.0	+1.4	+.5	+1.0	+1.1	+.2	+2.2
1929....	+.4	+2.6	+2.9	+2.3	+1.2	+1.5	+2.9	+1.4	+1.1	+1.4	-1.7	-.8
1930....	-2.6	+1.1	+.2	-.5	+1.4	+.7	+.9	+1.7	+1.3	+.5	-.7	+.9
Means..	63.9	63.4	64.8	66.8	68.3	70.2	71.0	71.9	71.6	70.2	68.1	66.2

TABLE E

DEPARTURES FROM AVERAGE OF MEAN MINIMUM TEMPERATURE

Station: Waiialua Mill

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	-1.8	— .6	+2.7	+ .2	+2.1	+ .7	+1.0	+1.8	+1.7	+ .5	+ .4	— .5
1906....	+ .3	— .2	— .8	+ .4	+ .4	+1.7	+ .3	+ .5	+ .6	— .3	— .8	+ .7
1907....	+2.4	+1.1	+ .7	—3.8	+ .5	+ .8	+1.1	+2.1	+3.1	+1.2	— .4	—2.3
1908....	—4.5	—2.5	—3.2	—3.8	—4.2	—2.7	— .3	— .7	—1.0	— .9	—3.3	— .4
1909....	— .5	+1.0	+ .1	—1.2	—1.8	—1.0	—2.5	—2.5	—1.7	— .3	— .7	+1.4
1910....	+ .4	— .6	+1.0	+ .3	— .5	+ .7	— .1	+ .9	+1.3	+ .5	+ .3	— .9
1911....	+2.2	+ .9	+1.4	+1.6	+ .6	— .1	+ .5	+1.6	+1.3	— .7	+ .8	+ .4
1912....	— .2	+ .4	—1.0	— .3	+ .3	+ .3	+ .7	+1.0	+ .5	+2.0	+ .7	+2.3
1913....	+ .8	+ .2	+1.0	+1.1	+ .2	+ .9	+ .6	+2.1	+1.4	+1.9	+2.8	—1.0
1914....	0	— .6	— .1	+ .7	+1.4	+1.6	+3.4	+4.0	+3.3	+1.2	+ .6	+ .7
1915....	+2.5	+1.8	+1.0	+ .8	+1.9	+1.2	+1.3	+2.2	+2.0	+1.9	+3.1	+3.3
1916....	+2.4	+2.1	+2.4	+1.8	—1.5	+1.1	+1.0	—1.2	— .5	+1.2	+ .7	— .5
1917....	— .6	+ .2	+1.2	+2.6	— .3	— .5	—1.6	—1.4	— .7	— .1	— .3	+1.4
1918....	+ .1	+1.0	+ .6	+1.0	+ .5	+ .4	+3.2	+2.0	+1.6	+2.1	+2.7	+2.6
1919....	+1.3	+3.7	+ .7	+ .9	+ .9	+1.4	+1.5	+2.1	+ .3	+ .4	+ .1	+ .6
1920....	+1.0	+1.1	+ .2	+ .3	+1.2	+ .9	+ .6	+1.2	+ .2	+ .6	— .2	+1.5
1921....	+3.7	+1.1	+ .7	+ .3	+ .8	+2.5	+1.6	+ .7	+ .8	— .6	+1.3	+ .6
1922....	+1.0	+1.1	+ .7	+ .1	— .7	— .5	— .5	— .5	+ .3	+ .5	+ .7	—1.3
1923....	+1.7	+ .1	+ .8	+ .4	— .1	—1.4	—1.1	—1.9	—1.4	—1.6	—1.9	—1.5
1924....	—5.0	—2.5	—3.5	0	+3.9	+1.9	— .2	—2.4	— .2	— .3	—1.3	—3.1
1925....	—2.8	—2.8	—2.6	— .4	— .1	+ .2	— .3	+1.2	— .9	+ .1	+ .4	+ .4
1926....	—1.2	— .9	—4.0	—6.4	—2.6	—2.9	—1.2	—2.0	—2.7	—2.1	— .7	+ .5
1927....	0	+ .7	+ .2	— .2	+ .6	—2.0	—3.3	—3.4	—2.9	—2.5	+ .7	— .3
1928....	— .7	—4.5	—3.1	—1.5	—3.5	—4.3	—3.2	—2.8	—3.5	—4.7	—3.7	—3.0
1929....	—2.8	— .1	+ .7	+ .1	0	+ .8	—1.0	—2.8	—1.8	—1.5	—3.6	—2.5
1930....	—1.0	0	+1.7	—2.1	+1.1	— .5	—2.1	—2.3	— .4	+ .7	+1.6	+1.8
Means..	60.7	60.0	60.8	62.6	63.9	65.4	66.6	67.0	66.4	65.4	63.9	62.1

TABLE E

DEPARTURES FROM AVERAGE OF MEAN MINIMUM TEMPERATURE

Station: Waianae

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	—2.5	—1.2	+1.4	+1.5	+ .8	+ .2	+2.8	+1.8	+ .2	+ .1	— .4	
1906....	+1.6	0	—2.4	— .7	+1.2	+4.2	+1.5	+ .9	+1.0	+1.7	— .1	+1.2
1907....	+1.4	0	+ .7	—3.0	—2.9	—4.9	—4.9	+2.6	+2.2	+1.8	+1.7	+ .8
1908....	+ .9	+ .9	+ .7	+ .1	+ .9	+ .7	—1.7	—1.0	— .9	—1.6	—2.3	+1.9
1909....	+1.5	+ .1	+ .4	—1.3	....	....	+1.5	— .1	— .6	— .4	— .9	— .5
1910....	+ .6	—1.4	+ .8	—1.0	—6.2	—6.6	....	— .6	—1.2	— .6	—1.2	— .8
1911....	+ .9	— .3	— .5	— .9	—1.3	+ .8	+1.4	+ .9	+1.2	—2.9	— .4	—1.1
1912....	— .3	+1.2	—2.2	— .7	— .2	—1.2	— .8	— .8	—1.0	+1.4	—1.2	— .2
1913....	—1.2	+ .1	+ .9	+ .2	—3.1	—2.3	—1.7	+ .1	— .8	—1.2	0	—3.0
1914....	—1.3	— .3	—3.2	—1.6	—2.0	0	+1.1	+1.6	+1.4	—1.0	—1.9	— .7
1915....	—3.4	— .4	—1.8	—3.3	+ .7	+1.6	+1.2	+ .6	— .2	+2.6	+1.5	+1.3
1916....	— .7	+ .8	+ .5	+ .8	+1.5	+ .8	+ .6	—1.5	— .6	—1.0	0	+ .4
1917....	— .9	—1.5	— .7	—2.4	—2.7	—1.0	—2.3	—2.9	—2.2	—2.8	—1.7	—2.3
1918....	—1.9	—1.1	—3.2	—1.7	—1.6	+ .1	+ .5	— .2	—1.3	—1.0	— .5	—2.1
1919....	—1.5	+ .8	—1.0	— .8	—1.6	—1.1	— .3	+ .3	—2.3	—1.1	—2.6	—1.6
1920....	— .8	— .9	—2.8	+1.9	—1.1	—4.1	—6.1	—3.5	—3.1	+ .3	—1.3	+ .7
1921....	+4.3	+ .4	—1.1	+1.1	— .2	—2.7	—3.3	— .2	+1.0	— .6	+ .9	+2.3
1922....	+1.8	+2.2	— .2	+ .5	+ .5	+ .3	0	+ .5	+ .7	— .6	— .4	—1.7
1923....	+3.3	— .9	+ .9	— .1	+2.3	+ .5	+2.3	—1.9	— .2	+ .2	+1.0	+1.3
1924....	—2.5	—1.7	— .3	+ .4	+1.1	+2.8	+ .6	—2.2	— .8	+1.1	+ .9	+3.1
1925....	+3.5	+2.9	+5.6	+4.0	+1.7	+1.1	+ .1	—1.3	— .3	+ .5	+1.7	—3.3
1926....	—1.3	+1.9	+2.0	— .8	+3.6	+1.0	— .4	2.4	+ .3	0	— .2	+4.3
1927....	+2.6	—2.9	0	+2.7	+3.2	+2.8	+3.2	+2.7	+1.7	+2.3	+4.2	—4.5
1928....	4.0	—1.7	+2.2	+2.9	+1.7	+1.2	+3.8	+2.0	+2.7	+2.3	+2.1	+3.7
1929....	0	+ .8	+2.3	+2.0	+1.5	+2.8	+2.8	+1.5	+1.1	+1.9	— .6	— .3
1930....	1.8	+4.7	+3.9	+4.0	+3.0	+2.3	+1.4	+2.9	+2.5	—1.6	+ .1	+1.4
Means..	62.4	62.0	63.6	65.3	66.7	68.0	69.8	70.9	70.0	68.6	66.4	64.2

TABLE E
DEPARTURES FROM AVERAGE OF MEAN MINIMUM TEMPERATURE
Station: Waimanalo

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	-4.2	-2.7	....	-4.3	-.2	-.8	-.3	0	-.5	-.6	+.2	+.6
1906....	+.1	-1.2	-4.2	-.1	-7.4	+1.5	+.5	+.5	-.1	+1.2	+1.2	+.9
1907....	+2.3	+1.8	-.2	-1.7	0	+1.6	+1.1	+.9	+1.5	+1.1	-.1	+2.1
1908....	+.9	+2.2	+1.1	+1.4	+2.0	0	-.4	-.5	-.1	-.2	-1.0	+1.2
1909....	+.7	+.4	+.1	-1.1	+1.1	+.3	-.4	-.2	-.3	-.8	-1.1	+.2
1910....	+1.5	-1.2	+.8	+1.4	-1.3	-.7	-.6	-.6	-.8	-.7	+1.0	-1.7
1911....	+1.9	+.3	-.6	+1.5	+.4	+.1	+.2	+.9	-.1	-1.3	+1.0	+1.3
1912....	+.5	+.6	-.2	+1.3	+.7	0	+.3	+.3	-.1	+2.2	+1.0	+3.5
1913....	-1.1	0	+.2	+2.1	+.6	+.4	+.4	+1.0	-.2	+.6	+2.4	-2.1
1914....	-1.2	-.8	-1.8	-.3	-.2	+.6	+.3	-.7	+.7	0	-.2	+.9
1915....	+2.4	+.3	-.5	-.7	+1.3	+.8	+.7	+.5	+.5	+1.3	+1.3	+1.6
1916....	+.6	+1.4	+2.4	+1.8	+.6	+.8	+.4	-.9	+.1	+.9	+1.7	+1.3
1917....	-.6	-1.8	+1.2	+1.4	+.5	+.9	-.3	+.4	-.5	-.4	+.5	
1918....	+1.5	+.9	-.3	-.2	-.2	-.1	+1.3	+.6	+1.1	+2.2	+1.2	+1.7
1919....	+1.0	+2.6	+.3	+1.1	+.3	+.3	+.2	+.2	-.5	+.9	+.3	-.2
1920....	-1.0	+1.5	-.6	-1.0	-.5	+.8	+.7	+.7	+.3	+.4	-4.1	-7.0
1921....	-4.9	-.4	-.7	+.9	-.2	+1.0	+.2	0	+1.2	-.1	-.2	-.1
1922....	+.2	+1.2	+.7	+.8	+1.4	-.3	+.7	0	-.4	-.5	-.6	-.5
1923....	+1.7	-2.1	-1.2	+1.4	+.5	-.9	-.4	-.1	+.8	-.6	-1.1	-3.0
1924....	-.9	+.2	-2.0	-2.0	-.1	-.9	-.8	-2.0	-.2	-.8	-.9	-.7
1925....	+.9	-1.6	+.8	-.2	-.3	-.7	-.6	-.3	+.9	-1.9	-.6	+.7
1926....	....	-3.8	0	-6.6	0	-2.0	-.4	-.5	-1.1	-1.5	-.3	-.9
1927....	-2.8	-3.4	+.2	-2.0	+.4	-1.2	-1.1	-.6	-.6	-.5	-.5	-1.3
1928....	+1.0	+1.2	+1.5	+2.1	-.6	-.6	-2.3	-1.1	-1.3	-.5	-2.4	-.9
1929....	-.3	+3.5	+1.7	+2.4	+.6	+.1	+.3	-.1	0	-.4	-.5	-1.1
1930....	+.8	+1.3	+.6	0	+.9	+.2	+.1	+1.4	+1.2	+.7	-.4	+1.8
Means..	64.4	64.6	66.0	67.4	69.2	71.3	72.5	73.0	72.8	71.1	69.1	66.8

TABLE E
DEPARTURES OF MEAN MINIMUM TEMPERATURE FROM AVERAGE
Station: Waipahu

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1906....	+.1	-.3	-2.5	+.7	+1.5	+2.8	+5.7	+1.6	+1.5	+2.1	-1.9	+2.0
1907....	+3.2	+2.5	+1.0	-1.9	-.2	+.5	+.1	+2.9	+1.2	+.5	-.1	+.5
1908....	-.7	+.8	+1.4	-.3	+.8	-.5	-1.2	-.6	0	-.6	-1.8	+.2
1909....	-.9	+.2	+.4	-1.5	-.5	+.3	-.6	-2.1	-1.4	-.5	-1.4	-.5
1910....	+.1	-1.6	-.5	-.6	-1.4	-1.2	-2.2	-2.2	-1.4	-1.5	-.1	-2.4
1911....	0	-.3	-1.2	-.5	-1.1	-1.0	-1.0	-.5	+.4	-2.4	-.8	-.4
1912....	-1.2	-.1	-2.4	-.3	-.7	-1.4	-.9	-.5	-.6	+.4	-.9	+1.3
1913....	-.3	-2.0	-.8	+.2	-1.4	-.6	-.9	-.3	-.8	-.4	+1.9	-2.3
1914....	-2.1	-1.6	-1.9	-1.1	-1.3	+.1	+1.6	+2.0	+1.8	0	-1.1	-3.2
1915....	-2.0	-.6	-2.4	-1.1	+.7	-.1	-.1	+.4	+.1	-2.0	+.8	-.1
1916....	+.8	+.4	+.6	-.3	+.3	-.8	-1.5	-2.6	-1.3	-.7	-.1	-.6
1917....	-1.6	-1.8	0	-.9	-1.7	+.9	-2.4	-2.2	-1.7	-2.3	-.8	-1.0
1918....	-.5	-.1	-1.1	-.7	-2.1	-1.1	+.1	-.6	-1.3	+.5	-.3	0
1919....	-2.3	+.5	-1.5	-.7	-.9	-1.4	-.5	....	-1.8	-1.5	-1.7	-2.0
1920....	-2.0	-1.2	-.4	-1.3	-1.8	-1.0	-.8	-.7	-.9	-.4	-1.2	-.2
1921....	+1.8	0	-.8	+.5	-1.6	+1.1	+.2	-1.6	-.8	-1.9	-.8	0
1922....	-.4	+.8	-.9	-.5	-3.0	-2.0	-1.1	+.5	-1.1	+.6	+1.1	-2.1
1923....	+1.6	-2.5	-.9	-.3	-.3	-1.0	-1.8	-2.3	-.7	-.7	-1.3	....
1924....	....	....	+3.7	+4.4	+3.8	+1.4	+1.9	+2.0	+3.2	+2.8	+3.1	+3.2
1925....	+3.5	+3.3	+3.8	+3.1	+2.8	+3.2	+3.3	+3.0	+1.1	+2.0	+2.8	+2.9
1926....	+2.4	+2.5	+2.2	-.1	+3.1	-.8	-1.2	-.2	+.9	+1.8	+.8	+3.0
1927....	+3.5	+1.6	+4.0	+2.3	+4.0	+2.9	+2.5	+2.1	+2.0	+2.2	+3.2	+.9
1928....	+1.4	-1.6	+.6	+.9	+.2	-.7	+.5	-.1	-.6	-.1	+.3	+.2
1929....	-1.8	-.2	+.3	+.8	+.7	+.6	+.2	+.3	-.2	+.7	-1.3	-.8
1930....	-2.5	+.5	-.3	-1.2	+.2	+.2	-.1	+1.7	+1.4	+.7	+.9	+1.4
Means..	62.3	61.7	63.0	64.5	65.8	67.7	69.0	69.6	68.9	67.7	66.0	64.1

TABLE F
MEAN DAILY RANGE OF TEMPERATURE

Station	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
OAHU													
Ewa	17.7	19.2	18.3	18.3	19.0	18.8	18.3	18.2	18.7	18.7	18.0	17.4	18.4
Kahuku	13.9	15.3	13.3	12.1	12.4	12.3	12.7	12.1	13.0	13.6	13.1	13.4	12.9
Waiialua	17.0	18.5	18.5	18.5	19.9	20.5	20.5	20.2	20.0	18.8	17.1	16.7	18.9
Waianae	18.3	19.2	18.4	18.2	18.8	19.1	19.0	19.2	18.7	18.8	18.7	18.8	18.8
Waimanalo	13.2	14.0	12.9	12.2	12.7	14.3	12.4	12.4	12.6	13.2	12.2	11.8	12.8
Waipahu	15.8	17.6	16.9	16.4	17.4	16.8	16.4	16.4	17.1	16.9	16.1	15.6	16.6
KAUAI													
Eleele	15.8	16.7	16.4	15.4	14.8	14.1	13.1	14.4	14.2	14.9	14.3	14.9	14.9
Kealia	15.7	16.7	15.0	13.9	13.7	12.9	12.9	13.0	13.8	14.1	14.2	14.6	14.2
Kilauea	14.7	15.9	14.3	13.4	14.2	13.5	13.4	13.0	13.8	13.7	13.2	13.5	13.9
Koloa	15.1	15.9	14.5	13.9	13.4	13.0	13.4	13.7	14.4	14.7	13.8	13.6	14.1
Lihue	16.3	17.2	15.5	14.3	14.3	13.8	13.8	13.8	14.4	15.1	14.8	15.0	14.9
Makaweli	16.4	17.4	16.9	17.0	17.0	16.7	16.8	17.2	17.0	17.0	16.3	16.4	16.8
MAUI													
Hana	13.3	13.9	12.9	11.9	12.6	12.1	11.9	12.2	14.5	13.0	12.7	12.8	12.8
Kaanapali	17.7	19.2	18.3	17.9	19.0	19.0	19.8	20.2	20.1	20.1	18.8	17.9	19.0
Puunene	15.4	18.2	16.5	15.5	16.5	16.2	15.9	15.4	16.1	16.7	16.0	15.1	16.1
Wailuku	14.6	15.7	14.8	14.0	14.3	14.0	13.4	13.8	14.0	14.6	14.3	13.7	14.3
HAWAII													
Hakalau	13.1	13.9	13.0	12.8	12.9	13.1	12.7	12.7	13.4	13.2	13.1	13.1	13.1
Hilo	14.8	15.5	14.5	13.9	14.8	14.5	14.4	14.1	14.8	14.8	14.4	14.6	14.5
Honokaa	16.2	17.1	16.4	15.9	15.9	16.5	15.8	15.4	16.4	16.5	16.1	15.4	16.1
Kohala	15.0	15.0	14.4	13.8	14.5	13.6	13.1	13.0	13.2	14.4	14.1	13.7	14.0
Olaa	19.6	21.2	20.0	18.2	18.5	18.4	17.9	17.5	18.1	18.6	18.3	16.7	18.6
Ookala	14.6	15.1	14.8	14.1	14.7	15.4	15.2	14.9	14.2	15.0	14.5	14.2	14.7
Pahala	19.4	20.1	19.4	19.3	19.4	19.8	20.6	20.5	20.2	19.8	19.4	19.0	19.7
Pepeekeo	14.3	14.9	14.1	12.6	13.6	13.7	13.5	13.5	13.4	14.6	14.3	14.2	14.0

TABLE G-I

EXTREMES OF MEAN MAXIMUM TEMPERATURE

Station	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
OAHU												
Ewa	81.5	84.0	82.1	83.7	85.2	87.0	87.6	88.5	87.9	87.2	84.0	82.3
	73.5	75.4	75.7	77.7	79.8	81.5	82.4	82.4	81.9	80.1	79.0	75.6
Kahuku	80.2	82.8	80.9	82.4	83.9	86.0	87.5	87.2	87.3	87.6	84.6	86.0
	74.2	75.8	74.3	76.6	77.8	79.8	81.0	81.3	81.3	80.4	78.7	77.2
Waialua	81.4	81.0	83.5	84.3	86.9	90.2	92.2	91.9	89.3	87.9	82.9	81.7
	74.8	74.6	76.9	78.4	81.4	82.8	83.9	82.0	81.8	80.2	78.2	76.3
Waianae	87.4	85.6	86.1	86.6	87.3	89.5	91.1	91.6	90.5	90.4	89.5	89.1
	78.0	78.8	78.8	79.4	84.2	83.3	86.7	87.9	84.2	81.5	82.4	79.2
Waimanalo	80.6	83.0	82.1	82.4	88.0	87.3	87.3	88.9	88.6	87.6	84.2	86.2
	75.1	74.8	76.4	76.0	76.0	78.4	81.5	82.0	81.4	80.1	77.3	73.8
Waipahu	82.1	84.3	86.0	84.3	85.7	86.8	87.3	87.7	87.7	88.1	85.0	84.4
	74.4	76.9	77.2	77.0	81.4	82.0	81.2	81.0	81.5	80.7	79.4	76.0
MAUI												
Hana	82.1	83.2	84.0	82.8	85.3	85.0	84.3	84.0	86.2	85.3	82.9	82.3
	73.6	72.4	72.5	75.2	77.3	77.8	80.2	80.7	78.9	78.2	76.8	73.3
Kaanapali	87.1	85.4	84.8	86.3	89.1	89.3	91.2	92.9	93.0	92.3	92.9	87.5
	73.7	75.3	76.6	75.6	83.2	84.6	86.0	86.0	80.3	80.0	77.7	74.5
Wailuku	80.7	82.0	82.3	82.4	85.3	85.9	87.0	87.7	88.4	86.7	84.6	83.5
	70.8	71.8	69.7	75.1	76.7	75.4	76.8	77.6	81.9	80.6	75.3	72.5
KAUAI												
Eleele	82.6	84.4	84.7	82.1	83.9	85.5	86.2	89.1	87.9	86.3	85.8	83.9
	72.8	75.6	75.8	76.4	78.6	80.0	78.9	80.9	80.5	80.5	78.8	75.6
Kealia	81.0	81.4	83.4	82.8	85.2	85.9	88.2	88.7	90.0	87.7	85.0	82.8
	73.8	75.2	70.7	76.6	77.9	79.6	80.2	80.7	80.8	79.7	79.0	76.4
Kilauea	82.6	81.3	82.8	81.6	83.2	84.9	85.4	86.2	86.2	85.2	82.3	81.8
	72.5	74.6	74.1	72.7	77.1	78.7	80.5	81.1	80.6	79.0	74.4	73.0
Koloa	80.0	79.6	79.6	79.9	80.9	83.5	83.8	84.8	85.1	84.7	82.1	80.0
	73.6	74.4	73.5	73.9	77.6	79.1	79.1	80.5	81.1	80.5	76.0	74.1
Lihue	79.0	80.6	80.0	80.1	83.0	84.0	85.5	86.3	86.2	82.6	81.2	85.1
	74.2	74.1	74.4	74.7	77.4	79.0	81.4	81.8	80.4	74.0	74.6	81.3
Makaweli	82.0	82.6	82.4	84.6	85.6	88.9	88.4	88.8	88.6	87.0	85.4	85.4
	71.4	74.5	75.5	78.6	81.6	82.8	83.1	85.4	84.1	82.3	75.8	74.0
HAWAII												
Hakalau	81.3	80.1	78.7	81.0	84.1	84.5	84.1	83.5	84.4	83.7	82.6	81.6
	68.6	72.5	73.2	74.4	76.3	71.5	78.4	79.2	78.7	78.5	75.4	71.9
Hilo	80.7	81.8	80.0	82.0	84.7	85.1	84.8	84.5	86.3	84.6	82.4	83.2
	74.8	72.8	73.3	74.9	77.5	77.4	77.6	80.1	79.2	77.2	74.5	75.1
Honokaa	82.0	82.2	82.6	84.9	76.4	85.9	86.3	86.7	85.9	86.0	83.6	84.2
	73.4	75.4	73.1	73.9	77.0	78.5	79.4	79.2	79.3	79.0	77.4	74.7
Kehala	80.0	80.6	80.7	81.1	83.1	85.6	85.6	86.6	84.3	86.4	82.5	82.3
	73.9	72.8	74.0	75.2	77.0	77.5	78.6	78.9	78.3	79.1	77.2	73.5
Olaa	86.3	87.7	86.7	83.9	85.5	89.0	87.5	89.7	90.0	89.0	87.0	89.2
	75.4	75.9	76.8	73.4	74.4	75.6	76.1	78.8	78.9	77.0	74.1	72.7
Ookala	82.3	81.2	81.8	82.9	84.0	84.8	85.1	85.4	86.5	85.5	83.0	85.4
	73.6	72.5	74.0	75.0	76.6	77.4	78.6	79.2	78.1	78.4	77.3	74.8
Pahala	80.8	82.3	81.8	82.4	84.1	85.2	87.5	87.3	87.8	86.9	85.9	83.6
	73.5	75.0	77.0	77.8	78.0	78.6	80.6	80.9	79.6	81.0	78.5	76.8
Pepeekeo	81.8	82.4	81.9	80.6	83.0	82.9	83.6	85.0	86.2	85.0	84.2	83.1
	72.6	71.6	70.9	72.4	74.3	75.1	76.2	77.3	78.4	77.5	76.0	74.3

TABLE G-II
EXTREMES OF MEAN MINIMUM TEMPERATURE BY MONTHS

Station	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
OAHU												
Ewa	64.5	62.3	64.3	65.3	66.7	69.2	70.1	71.5	71.5	69.0	67.1	66.1
	55.2	57.3	58.6	60.7	62.2	62.7	64.9	65.0	63.8	62.6	61.5	59.5
Kahuku	70.1	68.7	67.7	71.4	70.2	72.6	73.9	74.1	73.2	72.9	70.9	71.3
	60.8	60.9	62.1	63.2	66.5	67.4	67.4	68.8	68.6	67.7	64.6	62.5
Waialua	64.4	63.7	63.5	70.4	67.8	67.9	70.0	71.0	69.7	67.5	67.0	65.4
	55.7	55.5	56.8	56.2	59.7	61.1	63.4	63.6	63.5	60.7	60.2	59.0
Waianae	66.7	66.7	69.2	69.3	70.3	72.2	73.6	73.8	72.7	71.2	70.6	68.5
	58.4	59.1	60.4	62.0	60.5	61.4	63.7	67.4	66.9	65.7	63.8	59.7
Waimanalo	66.8	68.1	68.4	69.8	70.6	72.9	73.8	74.4	74.3	73.3	71.5	68.9
	59.5	60.8	61.8	60.8	61.8	69.3	70.2	71.0	70.8	69.2	65.0	59.8
Waipahu	65.8	65.0	67.0	68.9	69.8	70.9	72.3	72.9	72.1	70.5	69.2	67.3
	59.8	59.2	60.5	62.6	62.8	65.7	66.6	67.0	67.1	65.3	64.1	61.7
KAUAI												
Eleele	66.3	66.6	67.2	67.4	77.7	72.3	74.6	74.6	74.2	71.1	70.8	68.6
	59.2	58.8	59.8	62.1	63.4	65.5	67.4	67.3	67.0	65.9	63.7	61.7
Kealia	67.0	65.0	67.1	69.1	70.8	71.9	73.7	75.4	73.6	72.7	69.7	68.6
	56.3	59.0	57.6	60.2	62.1	63.6	64.1	63.2	64.2	63.5	62.8	59.2
Kilauea	64.5	63.9	64.8	65.9	67.2	69.3	70.6	72.6	70.5	69.9	67.8	65.8
	58.2	58.4	59.5	61.6	64.3	65.2	67.0	67.8	67.7	66.5	63.4	60.0
Koloa	65.3	64.0	65.5	67.0	68.2	70.6	71.7	72.9	72.3	70.5	68.8	67.0
	57.0	58.5	57.0	56.7	61.3	67.3	69.4	68.9	68.8	66.8	63.8	60.6
Lihue	64.4	62.8	64.9	66.8	68.5	70.0	71.1	72.8	71.1	69.9	67.9	66.2
	55.6	57.1	57.2	60.2	63.3	65.6	63.3	64.6	66.9	65.8	61.3	59.1
Makaweli	65.0	64.6	65.8	66.0	67.8	70.7	71.1	72.1	71.2	70.8	69.0	68.2
	57.6	59.9	60.5	61.4	64.3	66.9	67.2	66.5	64.8	64.0	63.2	60.6
MAUI												
Hana	67.8	68.9	68.8	69.8	72.1	72.8	74.0	74.2	71.3	72.4	71.3	69.4
	58.8	59.3	57.3	62.2	61.5	65.3	65.5	65.1	64.0	64.8	63.0	62.5
Kaanapali	66.4	63.4	64.7	68.1	72.0	72.9	70.9	71.7	70.9	70.5	68.6	68.3
	54.5	55.1	56.7	57.7	59.0	62.4	61.6	62.7	62.4	62.0	59.5	56.7
Wailuku	66.1	64.7	66.7	67.0	69.3	70.9	72.9	73.5	77.0	70.9	69.4	66.8
	58.1	60.0	59.2	62.8	65.7	67.9	68.5	69.1	68.9	67.1	65.4	63.0
HAWAII												
Hakalau	67.6	66.1	67.0	67.5	77.9	69.1	71.5	72.1	71.4	71.4	70.2	68.5
	56.2	55.6	54.5	58.5	63.0	64.2	64.8	64.5	63.3	61.3	58.4	58.3
Hilo	64.3	64.6	65.7	65.9	67.7	68.6	70.8	70.8	70.0	68.6	68.0	65.4
	59.7	59.6	60.7	61.6	62.7	63.7	64.5	64.4	63.9	63.7	62.4	62.2
Honokaa	63.9	63.8	64.9	65.6	67.5	69.0	70.7	70.5	69.4	69.5	66.8	65.4
	57.6	57.5	58.3	59.2	61.0	63.0	63.9	64.1	63.9	63.1	61.7	60.7
Kohala	64.8	66.9	66.6	65.8	68.8	69.6	70.7	72.5	72.6	69.4	69.1	66.4
	55.9	60.6	60.1	58.6	58.8	63.5	61.8	62.5	66.0	60.0	64.1	63.0
Olaa	63.2	62.2	63.6	64.3	65.7	66.0	67.5	69.1	68.7	66.5	65.4	64.0
	53.9	49.7	55.2	54.2	51.6	53.4	57.5	60.3	62.0	60.0	59.6	58.3
Ookala	67.4	66.0	68.8	66.8	70.3	74.4	69.4	69.5	73.2	71.4	70.7	67.2
	59.3	60.3	60.0	61.9	61.8	58.5	61.0	61.8	66.2	64.3	64.5	62.1
Pahala	62.0	61.0	62.5	63.4	63.7	64.9	65.5	67.7	67.5	65.7	65.1	63.3
	56.0	55.5	54.9	57.1	58.5	58.9	59.5	57.9	57.2	57.9	59.1	58.1
Pepeekeo	66.1	65.3	65.4	66.3	67.7	68.4	69.8	70.3	70.6	68.9	68.6	66.4
	61.6	59.6	61.5	63.1	64.1	63.1	62.7	62.6	64.4	63.8	63.8	62.7

RAINFALL DATA

Rainfall data are available for 31 stations. We have omitted detailed presentation of the rainfall data on irrigated plantations as such data would be of little practical interest.

NORMAL MONTHLY RAINFALL

Table H gives the normal monthly rainfall of the plantations.

One characteristic feature of our monthly rainfall is that more rain falls in winter than in summer, whereas from the point of view of cane production we should have generally more rain in summer than in any other season.

MONTHLY RAINFALL DATA

Table I gives the rainfall by months of the unirrigated plantations from 1905-1930.

The importance of rainfall to sugar production is fully recognized. It is not the total annual rainfall that is of importance, but its distribution over the seasons. Ideal conditions would be—ample rain in summer when the cane is growing rapidly, and comparatively little rain in winter when the growth is slow or when the cane needs to be ripened. High yields in unirrigated plantations are associated with more or less ideal conditions. Fig. 8 shows the distribution of rainfall for some high-yield years and some poor-yield years at the Pepeekeo Sugar Company.

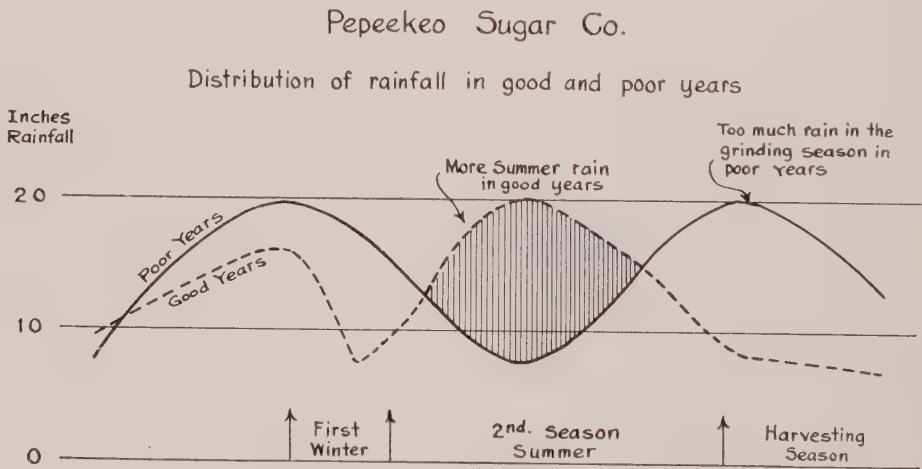


Fig. 8

A month-to-month progress of rainfall can be kept on a wall chart similar to that shown for temperature in Fig. 5. This will help the plantation to follow the progress of the crop intelligently. Probably data on seasonal rainfall will be just as useful because the deficiency of rainfall in one month of a season may be made up by an excess in another month of the same season.

The detailed table should be of help in studying the sequence of rainfall. Does one wet month follow another? Is there any periodic fluctuation, etc.?

MONTHLY RAINFALL EXTREMES (TABLE J)

Very often a plantation management wants to know the dependability of rainfall or how much rain to expect in a particular month or season. The arithmetical average of the data recorded is not always a safe guide. From the table of rainfall extremes (Table J), we see that at Pepeekeo the rainfall extremes for the month of August are 29.75 inches and 4.06 inches. It is just as possible to get 29 inches rain as 4 inches.

But for practical purposes, we want to know not what it is possible to get but the average expectancy of rainfall. For such purposes, it will be found advisable to study the distribution of rainfall in any particular month or season for the years of which we have record. We see that at Pepeekeo, for the month of August, in about 80 per cent of the years on record, rainfall varied between 5 inches and 15 inches, the mean of these years being 13 inches. Therefore, we would be justified in assuming that our chances are 8 to 10 that we shall get an average rainfall of 13 inches in August. In the case of Pepeekeo, this mean comes close to the arithmetic mean, but in some other cases, like Honokaa Mill, it will be found that the average expected rainfall is only two-thirds of the arithmetic mean.

As we have observed previously, it may be found of greater advantage to similarly study the seasonal variations and expectancy of total rainfall. Table K gives the seasonal rainfall extremes for Pepeekeo. It will be noted that seasonal variations are less than monthly variations.

TABLE H
* NORMAL MONTHLY RAINFALL OF ALL THE PLANTATIONS

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total Annual	Period Included in the Normals
OAHU														
Ewa	2.82	3.40	2.61	1.33	0.81	0.57	0.37	0.59	0.91	1.15	2.29	3.90	20.75	1891-1928
Kahuku	4.23	4.40	4.84	3.22	2.04	1.63	1.90	2.16	2.23	2.79	3.50	4.68	37.62	1891-1928
Waialua	4.34	3.93	3.80	2.72	1.34	0.94	1.07	1.06	1.47	1.52	3.08	5.49	30.76	1901-1928
Waianae	2.93	3.36	2.27	1.31	0.78	0.45	0.32	0.73	0.96	0.92	2.18	3.57	19.78	1891-1928
Waimanalo	5.81	5.09	5.86	4.46	2.57	1.54	1.33	1.61	1.79	2.53	4.49	6.15	43.83	1895-1928
Waipahu	3.66	3.38	3.36	1.59	1.27	0.72	0.46	0.85	0.99	1.48	2.19	4.36	24.31	1898-1928
KAUAI														
Elecle	4.82	2.85	4.33	2.03	1.53	1.08	1.29	1.00	1.88	2.00	2.58	4.14	29.63	1885-1928
Grove Farm	5.61	4.46	5.92	3.22	3.28	2.13	2.49	2.65	3.24	3.76	5.39	5.88	48.13	1899-1928
Kenia	4.75	3.33	5.60	2.89	2.29	1.71	2.01	1.81	2.72	3.30	4.08	5.42	39.91	1890-1928
Kekaha	3.70	2.75	3.42	1.23	0.95	0.55	0.56	0.80	1.10	1.38	2.15	3.69	22.28	1885-1928
Kilauea	6.51	5.31	8.79	5.68	5.03	3.73	4.63	4.57	4.90	5.34	7.14	7.09	68.72	1885-1928
Koloa	7.01	4.79	6.75	4.96	4.75	3.98	4.64	4.70	4.56	5.16	6.12	6.75	64.17	1887-1928
Lihue	7.25	3.46	6.23	3.93	3.50	2.48	2.93	3.05	4.24	4.20	5.10	6.80	53.17	1905-1928
Makaweli	3.58	2.46	3.71	1.24	1.09	0.81	0.69	0.56	1.20	1.45	2.25	3.77	22.81	1896-1928
MAUI														
Lahaina	2.73	1.27	1.90	1.33	0.41	0.10	0.08	0.06	0.29	0.40	0.64	2.92	12.13	1914-1928
Wailuku	4.97	3.55	3.83	3.53	1.38	0.56	0.70	0.95	0.87	1.18	2.38	5.04	28.94	1902-1928
Kaanapali	3.70	2.70	2.05	1.60	0.71	0.27	0.43	0.86	0.45	0.63	1.28	3.62	18.30	1892-1928
HAWAII														
Hakalau	13.50	9.46	13.15	13.59	9.85	8.52	10.74	13.73	12.18	10.54	14.97	14.81	147.04	1905-1930
Hilo	12.36	8.92	15.38	12.13	9.16	8.20	9.80	13.14	11.87	11.03	14.56	14.48	141.03	"
Honokaa	7.82	6.87	8.81	9.46	4.93	3.32	4.63	6.25	4.14	3.36	9.47	9.42	78.48	"
Kohala	5.53	4.20	4.97	6.59	4.21	3.79	4.89	5.41	3.89	2.97	6.00	6.11	58.56	"
Naalehu	5.32	3.88	4.71	3.39	2.03	1.55	1.83	3.19	2.91	3.71	4.75	5.87	43.14	"
Nuli	5.64	4.24	5.77	6.75	4.49	3.87	5.20	5.73	4.24	3.15	6.08	6.77	61.95	"
Olaa Mill	11.78	8.89	14.16	13.63	9.33	7.96	10.24	12.74	10.93	10.45	14.79	16.16	141.06	"
Ookala	10.36	8.68	12.55	13.67	8.10	6.20	8.89	11.48	7.30	7.06	12.14	12.26	118.69	"
Paauhau	6.99	6.00	7.87	8.19	4.72	2.95	4.33	5.74	3.73	3.00	8.10	8.08	69.70	"
Paauilo	8.95	7.14	10.45	11.33	6.23	4.31	6.10	8.06	5.45	4.03	10.29	12.55	94.89	"
Pahala	5.82	4.10	5.78	5.54	2.30	1.07	1.37	3.00	2.40	3.86	5.21	5.81	44.26	"
Papaikou	16.62	11.25	19.42	17.15	12.45	10.61	13.45	16.60	14.82	12.90	18.60	19.00	182.87	"
Pepeekeo	12.44	8.07	11.66	11.91	8.59	7.39	9.30	11.30	11.33	9.62	12.80	13.83	128.24	"
MAUI														
Hana	8.56	5.42	7.54	9.42	4.57	3.77	4.31	5.36	5.22	4.90	6.67	9.47	75.21	"

* The normals for the irrigated plantations include records up to 1928 and were obtained from the files of the U. S. Weather Bureau at Honolulu.

TABLES—I
RAINFALL DEPARTURES FROM NORMAL BY MONTHS
STATION HAKALAU
Data—Rainfall Departures

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.						
1905....	—	5.59	—	2.74	—	6.12	—	3.82	—	.11	—	1.65	—	7.13	—	.55	—	2.14
1906....	—	7.24	—	9.08	—	4.96	—	.99	—	.35	—	.39	—	8.31	—	6.54	—	2.22
1907....	—	5.36	—	.65	—	4.84	—	.50	—	2.68	—	1.51	—	19.61	—	3.93	—	8.31
1908....	—	6.05	—	14.57	—	8.65	—	4.67	—	2.20	—	1.14	—	3.33	—	2.44	—	.99
1909....	—	5.76	—	2.65	—	19.58	—	2.01	—	1.93	—	6.59	—	7.96	—	2.21	—	6.43
1910....	—	4.03	—	3.89	—	1.21	—	3.80	—	4.20	—	.25	—	1.10	—	5.20	—	4.94
1911....	—	5.44	—	13.67	—	4.06	—	5.39	—	6.60	—	.24	—	.89	—	.77	—	2.41
1912....	—	11.21	—	5.91	—	2.82	—	3.33	—	.74	—	1.56	—	5.37	—	6.60	—	4.84
1913....	—	18.84	—	8.25	—	1.27	—	2.36	—	1.21	—	3.12	—	6.60	—	6.17	—	5.42
1914....	—	4.97	—	3.01	—	1.88	—	20.31	—	10.34	—	7.14	—	23.48	—	1.38	—	3.23
1915....	—	9.39	—	11.37	—	8.82	—	6.70	—	1.89	—	1.83	—	9.12	—	2.86	—	2.45
1916....	—	.32	—	2.55	—	4.55	—	16.64	—	3.52	—	1.45	—	5.02	—	2.74	—	19.24
1917....	—	10.22	—	3.40	—	3.08	—	3.66	—	.19	—	4.29	—	10.32	—	7.48	—	8.42
1918....	—	7.01	—	13.35	—	13.61	—	5.49	—	3.31	—	16.61	—	3.02	—	2.75	—	2.66
1919....	—	7.41	—	4.53	—	9.27	—	3.85	—	3.92	—	4.40	—	4.13	—	3.24	—	7.20
1920....	—	7.11	—	13.36	—	7.72	—	9.62	—	5.81	—	2.88	—	6.76	—	9.71	—	6.43
1921....	—	22.44	—	7.55	—	4.97	—	7.55	—	5.50	—	2.02	—	1.19	—	.03	—	7.68
1922....	—	10.69	—	28.72	—	1.43	—	3.17	—	6.75	—	4.73	—	6.21	—	2.47	—	3.24
1923....	—	26.47	—	9.90	—	13.86	—	1.73	—	1.18	—	1.42	—	.40	—	6.94	—	10.49
1924....	—	9.85	—	7.85	—	6.28	—	4.18	—	4.70	—	2.41	—	2.80	—	4.86	—	8.38
1925....	—	3.57	—	11.27	—	3.62	—	.95	—	.79	—	7.05	—	1.94	—	.01	—	8.79
1926....	—	10.05	—	13.61	—	9.98	—	3.92	—	6.05	—	6.41	—	3.02	—	7.19	—	3.24
1927....	—	1.02	—	.23	—	2.26	—	1.41	—	2.50	—	.01	—	.20	—	.39	—	10.96
1928....	—	5.20	—	11.32	—	8.22	—	3.28	—	.96	—	2.30	—	4.76	—	.02	—	3.72
1929....	—	1.38	—	1.40	—	3.84	—	5.60	—	4.52	—	4.67	—	4.01	—	7.42	—	28.94
1930....	—	4.34	—	1.55	—	13.09	—	2.95	—	8.87	—	3.18	—	5.57	—	4.17	—	3.89
Means..	13.50	9.46	15.15	13.59	9.85	8.52	10.74	13.73	12.18	10.54	14.97	14.81						3.41

Annual—147.04

HILO STATION

Data—Rainfall Departures

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	-11.37	-3.89	-8.63	6.07	1.56	-.86	+.21	-1.03	+.698	-.94	+11.30	-2.73
1906....	-8.82	-6.93	-13.63	-3.81	+.09	-2.19	4.72	7.48	4.76	6.45	3.36	-2.83
1907....	-6.67	2.33	-1.44	-6.63	4.40	2.79	.61	24.63	14.41	5.83	3.82	-9.03
1908....	-3.38	+13.08	-7.33	3.21	+.02	1.92	1.84	3.93	1.41	.23	-7.87	1.10
1909....	-5.49	1.10	+14.15	-4.68	1.63	-.73	4.37	8.06	4.07	2.38	-10.47	2.61
1910....	+3.53	-6.05	2.35	-1.73	3.86	4.01	.64	5.04	7.91	8.39	4.62	-.88
1911....	+3.43	9.81	1.52	6.07	6.40	3.09	3.77	2.95	11.10	3.69	1.14	+.53
1912....	-12.10	6.91	+.57	2.31	1.47	1.76	3.38	8.65	4.74	7.51	+.04	3.05
1913....	+21.27	-3.16	-6.48	+.41	-3.70	4.32	-2.66	5.45	5.48	5.63	3.70	6.18
1914....	-5.34	4.53	-9.00	-1.01	11.32	17.27	13.65	15.07	12.19	4.6	16.84	+.58
1915....	-9.00	+.31	-12.76	9.77	-5.29	+.98	3.46	8.06	2.17	9.69	14.20	5.25
1916....	+4.08	-4.59	-6.06	+.30	12.30	1.75	1.02	-.60	1.51	3.4	36	8.58
1917....	+3.91	-4.98	3.77	+.07	5.31	3.20	7.72	+.97	5.28	6.58	37	8.01
1918....	+1.53	20.51	6.40	4.55	+.53	3.62	5.03	10.72	9.37	3.57	4.03	5.31
1919....	-6.80	-3.02	-3.76	-8.22	3.85	-2.85	-2.34	1.12	5.28	3.57	3.07	-10.59
1920....	-8.11	-4.20	11.93	-3.30	7.85	4.46	2.62	5.13	3.4	9.33	7.29	-.99
1921....	+3.84	-3.84	-10.94	-1.64	-6.80	-5.26	2.26	-2.60	4.47	2.87	12.64	1.36
1922....	+9.29	10.03	51.58	+.98	1.47	5.88	-4.46	5.92	4.62	1.82	2.76	-11.35
1923....	29.24	-1.41	9.97	10.71	1.05	-.48	+.27	26	5.03	2.04	7.74	17.87
1924....	-9.90	5.58	-7.90	7.04	1.14	4.76	3.20	34	3.95	14.05	5.70	-10.94
1925....	+1.40	-7.00	10.26	1.55	1.06	+.40	4.86	5.32	3.23	3.67	3.30	-13.16
1926....	-8.52	3.06	-13.34	-10.13	1.28	4.56	4.42	4.14	3.25	4.13	11.78	+.98
1927....	+1.16	-6.68	4.10	-1.73	3.12	-1.28	1.80	1.58	+.67	2.87	1.96	37.40
1928....	-4.56	-3.30	-10.84	-6.09	5.53	1.16	3.50	4.99	2.11	6.49	7.67	9.52
1929....	-3.92	6.23	2.04	-1.29	6.72	4.63	2.89	4.79	6.95	6.74	3.00	+.82
1930....	-5.99	-4.00	-3.53	10.32	1.09	8.42	+.80	9.66	3.22	1.73	4.04	-8.47
Means..	12.36	8.92	15.38	12.13	9.16	8.20	9.80	13.14	11.87	11.03	14.56	14.48

Annual—141.03

NAALEHU STATION

Data—Rainfall Departure

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	— 4.86	— 3.20	— 3.96	— 2.78	— .89	— .29	— .66	— .59	— .62	— 1.54	— 2.94	— 3.33
1906....	— 4.21	— 3.44	— 4.47	— 2.78	— .67	— .21	— .63	— 2.35	— 2.24	— 2.37	— 9.20	— .95
1907....	— 4.62	— 3.34	— 4.18	— 1.95	— .03	— 2.70	— .24	— 8.45	— 8.58	— .67	— 4.12	— 5.10
1908....	— 3.99	— .24	— 2.3	— 0.94	— 1.63	— 1.31	— 1.29	— 1.48	— 1.01	— 2.26	— 4.32	— 5.41
1909....	— 4.92	— .49	— 2.3	— 1.72	— .01	— .77	— .56	— 3.08	— 1.68	— 1.56	— 4.34	— 7.57
1910....	— 1.69	— 2.57	— 1.97	— 2.00	— 1.33	— .06	— .62	— 4.45	— .55	— 1.87	— 1.43	— 4.18
1911....	— .34	— 4.97	— 7.14	— 1.14	— .19	— .11	— 1.7	— 1.25	— 1.55	— .13	— 2.15	— 1.52
1912....	— 4.69	— .47	— 2.32	— 2.33	— .88	— .73	— 2.4	— .77	— 1.82	— 2.20	— 4.16	— 3.51
1913....	— 1.75	— 1.41	— 3.29	— 2.94	— 3.85	— 1.65	— 1.27	— .94	— 1.38	— 1.51	— 9.87	— 2.55
1914....	— 1.55	— 2.20	— .16	— 2.10	— 1.56	— 3.23	— 2.71	— 3.21	— 1.59	— .59	— 2.61	— 1.71
1915....	— 5.29	— 1.81	— 4.51	— .33	— .56	— 1.19	— 2.85	— 1.90	— 2.47	— 5.14	— 10.04	— 3.53
1916....	— 8.94	— 3.10	— 6.61	— .67	— 2.43	— 1.53	— 1.15	— 1.60	— 1.46	— .56	— 3.05	— 9.92
1917....	— 6.67	— .67	— 9.05	— .41	— .35	— .52	— 1.61	— 2.87	— 2.79	— 1.56	— 3.85	— 2.34
1918....	— 7.29	— 16.16	— .48	— 5.17	— .91	— .87	— 2.70	— .04	— 1.48	— 2.27	— 3.69	— 5.47
1919....	— 4.25	— 3.76	— 3.41	— 1.45	— .60	— .37	— 1.51	— 2.53	— .28	— 1.73	— .34	— 1.88
1920....	— 1.23	— 2.54	— .16	— 1.84	— 1.49	— .54	— 1.01	— 2.41	— .55	— 1.34	— 4.20	— .83
1921....	— 11.10	— .12	— 1.53	— 1.75	— .05	— 1.10	— .91	— .22	— .80	— 2.03	— 3.67	— 3.33
1922....	— 1.66	— 6.55	— 2.14	— 1.90	— 1.46	— .94	— .86	— 2.13	— .75	— .87	— 2.00	— 3.13
1923....	— 9.25	— 4.09	— 4.88	— 13.95	— .11	— .35	— 1.41	— .97	— 1.67	— 2.37	— 2.67	— 1.35
1924....	— 4.65	— 3.22	— .20	— 9.61	— .90	— .12	— .78	— 1.31	— 1.48	— 1.95	— 3.72	— 1.05
1925....	— 3.94	— 3.14	— 2.76	— 2.58	— 1.52	— .58	— .32	— 1.47	— .67	— .40	— 1.82	— 2.31
1926....	— 3.79	— 3.63	— 4.03	— 2.74	— .25	— .77	— .83	— 5.19	— 1.80	— 1.60	— 2.39	— 4.43
1927....	— 3.18	— 2.98	— 3.38	— 6.10	— .68	— .16	— 1.11	— 2.48	— 6.45	— .39	— 3.16	— 19.84
1928....	— 4.81	— 2.44	— 2.52	— .76	— .04	— .77	— 3.07	— 1.29	— 1.03	— .59	— 3.05	— 3.09
1929....	— .54	— 5.90	— 1.63	— 1.14	— .15	— .98	— .01	— 1.46	— 1.03	— 1.68	— 9.98	— 1.39
1930....	— 1.99	— 3.16	— 1.62	— 1.72	— .63	— .28	— .28	— .24	— 1.86	— 4.39	— 1.41	— 5.26
Means..	5.32	3.88	4.71	3.39	2.03	1.55	1.83	3.19	2.91	3.71	4.75	5.87

Annual— 43.14

NIULII STATION

Data—Rainfall Departures

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	- 2.96	- 2.00	+ 1.13	.. .61	+ 2.29	- .85	- .71	+ 1.10	+ 4.10	+ 1.19	- .92	- 1.30
1906....	- .75	- 2.36	- 2.38	+ .87	+ .16	- 1.86	+ 2.99	+ 1.37	- .89	- 1.65	- 1.47	+ 7.51
1907....	- 2.50	+ 3.13	+ .96	- 3.07	- 1.86	- .57	+ .31	+ 2.39	+ 3.70	+ 1.48	- .46	+ 4.63
1908....	- 3.64	- 1.00	- 3.16	- 3.93	+ .04	- 1.03	+ 2.94	+ 1.43	+ 1.29	- .29	- 2.47	+ .79
1909....	- 2.50	+ 1.40	+ 4.13	+ .45	+ .53	- 1.39	+ 1.40	- 4.86	- 1.11	- .75	- 2.49	- .26
1910....	+ 2.37	- 1.61	+ 2.05	- .90	- .14	+ 1.54	+ 3.75	- .47	- 2.33	+ 1.23	- 2.49	+ 5.12
1911....	+ 2.26	+ 4.46	+ 1.67	+ 1.14	- .70	+ 4.69	+ 1.37	- .82	+ 3.99	+ .02	+ .47	+ 4.55
1912....	- 4.63	+ 1.28	- .46	+ 2.73	- .42	- .33	- 2.49	- 3.12	- 2.13	+ 2.15	- .23	- 3.31
1913....	- 2.45	- 1.35	- 3.52	- 1.18	- .35	+ .97	- 2.10	- 1.33	- 1.32	- 2.24	+ 1.12	+ 1.11
1914....	+ .46	- 3.72	- .20	- 2.91	+ 10.07	+ 7.69	+ 9.58	+ 13.79	+ 4.96	+ 2.99	+ 5.93	+ 3.29
1915....	- 2.58	+ .97	- 3.60	+ 3.10	- 3.38	- .60	- .90	- 3.99	+ .42	+ 2.38	+ 2.51	- 1.47
1916....	+ 4.38	- 3.86	- .87	+ 2.63	+ 6.75	+ 2.68	+ 1.27	+ 2.13	- .22	+ 2.99	+ 3.52	+ 4.48
1917....	- .55	+ 1.27	- 2.07	- 4.78	- 2.28	+ 1.89	+ 3.86	- 4.48	- 3.65	- 2.15	- .17	- 4.77
1918....	+ 1.81	+ 5.53	+ 3.65	+ 12.05	+ 6.95	+ 3.59	+ 6.23	- .01	- 3.17	+ .95	+ 1.01	+ 8.34
1919....	- 1.90	- 2.79	- .50	- 3.04	- 2.00	- 2.61	- 2.04	- .10	- .61	- 1.65	- 4.97	- .25
1920....	- 1.28	- 2.53	+ 2.70	- 2.49	- 4.01	- 3.11	- 3.38	- 1.21	- .35	- 1.25	- 3.01	- 2.54
1921....	+ 5.49	- 2.12	+ 2.06	- 2.05	- 3.58	- 2.93	- .79	- 1.32	- .90	- .71	+ 7.86	+ 3.46
1922....	+ 2.72	+ .57	+ 6.15	- 1.59	- 2.29	- 2.94	- 3.36	- 2.34	+ 5.28	- .90	+ .13	- 5.60
1923....	+ 12.42	- 3.23	+ 2.15	- .30	- 1.72	+ 1.50	- .30	+ .70	+ .46	+ 2.26	- 1.81	+ 2.02
1924....	- 4.09	+ 3.00	- 2.96	+ 3.22	- 1.74	- 2.72	- 1.22	+ 1.08	- .75	+ 2.83	....	+ 3.88
1925....	+ .52	- 3.05	+ 3.02	- .96	+ 1.42	+ .48	- 3.24	+ .97	- 1.94	- 2.02	- 4.16	- 6.33
1926....	- 3.09	- .58	- 4.81	- 2.24	- 1.27	- 1.73	- 1.15	+ .27	- .82	- .69	- 3.52	- 4.99
1927....	- .63	+ .36	- 3.32	+ 2.98	- 1.74	- 1.30	+ 1.09	+ .96	- .53	- .29	- .25	+ 5.68
1928....	- 1.55	- .26	- 4.28	- 3.85	- .35	- .58	+ .90	- 1.97	+ 1.48	- 1.99	+ 1.50	+ 1.70
1929....	+ 1.91	+ 4.83	+ .13	- 1.96	- .79	- 1.30	- 1.91	- 2.09	- 3.91	- 1.21	+ 2.26	+ 4.83
1930....	+ 1.26	+ 3.54	+ 1.24	+ 6.64	- .29	+ 2.53	- 1.71	+ 1.92	- 1.00	- .17	+ 7.92	+ 4.41
Means..	5.64	4.26	5.77	6.75	4.49	3.87	5.20	5.73	4.24	3.15	6.08	6.77

Annual—61.95

OLAA MILL STATION

Data—Rainfall Departures

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905.....	—	2.75	—	9.38	—	1.98	—	2.18	—	5.34	—	1.67
1906.....	—	5.33	—	4.84	—	.71	—	7.22	—	1.58	—	1.59
1907.....	—	4.90	—	5.03	—	.03	—	2.17	—	5.15	—	10.96
1908.....	—	8.00	—	9.04	—	2.25	—	20.09	—	9.42	—	4.74
1909.....	—	3.70	—	1.58	—	1.06	—	2.96	—	.62	—	1.19
1910.....	—	15.35	—	8.09	—	1.67	—	2.42	—	.07	—	7.82
1911.....	—	1.88	—	4.45	—	1.84	—	7.25	—	2.81	—	11.61
1912.....	—	3.42	—	3.92	—	1.84	—	1.63	—	5.52	—	3.22
1913.....	—	10.18	—	6.12	—	.95	—	3.07	—	3.36	—	1.76
1914.....	—	1.01	—	2.03	—	3.32	—	3.17	—	3.22	—	1.10
1915.....	—	4.56	—	2.97	—	.06	—	7.54	—	9.35	—	4.23
1916.....	—	3.75	—	2.28	—	1.92	—	1.20	—	5.78	—	5.70
1917.....	—	4.04	—	2.34	—	2.29	—	1.48	—	4.48	—	4.71
1918.....	—	1.64	—	6.16	—	8.82	—	21.44	—	12.04	—	5.71
1919.....	—	5.73	—	7.47	—	.47	—	7.60	—	.53	—	23.80
1920.....	—	7.36	—	3.35	—	2.94	—	.87	—	.51	—	4.33
1921.....	—	2.19	—	4.63	—	.63	—	8.97	—	7.77	—	8.10
1922.....	—	1.83	—	1.59	—	4.06	—	1.03	—	5.06	—	.21
1923.....	—	6.44	—	4.43	—	1.16	—	3.94	—	6.03	—	11.72
1924.....	—	22.38	—	14.41	—	4.17	—	4.62	—	1.06	—	7.30
1925.....	—	4.13	—	7.67	—	4.00	—	4.62	—	2.61	—	5.91
1926.....	—	3.26	—	2.58	—	4.85	—	3.88	—	.88	—	2.84
1927.....	—	4.04	—	38	—	5.92	—	3.96	—	5.20	—	4.84
1928.....	—	3.65	—	9.37	—	.18	—	2.35	—	3.92	—	13.34
1929.....	—	1.14	—	10.48	—	4.01	—	2.72	—	1.48	—	12.11
1930.....	—	7.35	—	8.31	—	.55	—	3.86	—	6.14	—	14.55
1931.....	—	1.71	—	11.69	—	1.12	—	4.43	—	1.10	—	2.26
1932.....	—	6.43	—	1.55	—	5.84	—	4.43	—	1.78	—	2.26
1933.....	—	2.43	—	3.79	—	.94	—	1.78	—	1.89	—	32.08
1934.....	—	4.68	—	10.02	—	1.39	—	5.05	—	1.9	—	9.01
1935.....	—	2.61	—	1.11	—	3.52	—	3.24	—	5.96	—	2.04
1936.....	—	5.82	—	.82	—	4.34	—	7.00	—	7.61	—	9.79
Means....	11.78	8.89	14.16	13.63	9.33	7.96	10.24	12.74	10.93	10.45	14.79	16.16

Annual—141.06

STATION OOKALA

Data, Rainfall Departures

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	- 3.86	- 4.66	+ 2.56	- 5.08	- .23	+ .16	+ .95	+ 3.99	....	+ 9.06	+ 4.10	- 3.04
1906....	- 8.69	- 6.68	- 6.62	+ .39	+ .17	- 1.73	+ .64	+ 2.31	- 3.69	- 3.92	- 4.09	- 3.89
1907....	- 7.38	+ 3.27	+ 3.39	- 2.79	- 4.41	+ 3.24	+ 2.34	+ 18.90	+ 13.05	+ 1.80	- 4.57	- 8.53
1908....	- 5.72	+ 1.70	- 9.06	- 2.79	- .12	- 1.46	+ 2.95	+ .33	+ 5.06	+ 3.04	- 1.93	+ 8.38
1909....	- 2.88	- .42	+ 18.91	+ 2.16	- .61	- .51	+ 1.29	- 9.19	- 2.37	- 1.47	- 6.85	+ 1.62
1910....	+ 6.46	- 1.98	- 1.75	- 6.01	+ 3.37	+ 4.70	- .34	+ 1.47	- 5.23	+ 2.26	+ .34	+ 13.04
1911....	+ 2.88	- 14.82	- 3.19	+ 3.21	+ 2.97	+ 5.00	- .63	+ 3.49	+ 6.88	- 3.16	+ 1.61	- 4.25
1912....	- 7.88	+ 3.84	- 1.13	....	- 2.38	- 2.43	- 4.97	- 6.61	- .29	+ 6.40	- 2.33	- 2.58
1913....	- .29	- 1.25	- 7.39	- 3.43	- .80	....	- 5.87	- 5.45	- 4.00	- 5.67	+ 10.75	- .65
1914....	+ 3.11	- 4.80	- 2.24	- 2.10	+ 17.13	+ 10.88	+ 21.77	+ 27.21	+ 13.10	+ 1.24	+ 6.26	- 1.13
1915....	- 2.84	+ 2.24	- 6.99	+ 3.66	- 3.88	+ .80	- 1.32	- 10.32	- 1.34	- 2.55	+ 11.59	- 4.95
1916....	+ 1.16	- 6.74	- 3.10	- .23	+ 15.79	....	+ 1.62	- 2.04	- 3.14	- 4.11	- 2.81	+ 13.93
1917....	- 6.47	- 2.28	- 5.46	- 9.59	- 4.06	- 1.36	- 5.97	- 10.71	- 6.71	- 4.02	+ 2.73	- 5.46
1918....	+ 1.72	+ 17.64	+ 6.11	+ 36.40	+ 8.88	+ 5.73	+ 13.43	+ 2.87	- 4.55	- 1.99	+ 5.33	+ 13.27
1919....	- 1.96	- 3.38	+ 1.77	- 7.21	- 2.81	- 5.21	- 6.20	- 5.73	- 2.63	- .37	- 10.91	- 2.44
1920....	- 6.39	- 6.69	+ 6.58	- 8.26	- 8.01	- 4.46	- 3.86	- 5.62	- .08	+ 2.15	- 5.86	- 4.66
1921....	+ 28.87	- 5.26	- 1.61	- 5.29	- 4.95	- 4.75	+ 1.62	- 1.34	- 1.45	+ 2.33	+ 13.04	+ 2.12
1922....	+ 6.99	+ 3.80	- 7.25	- 5.09	- 2.79	- 4.51	- 5.62	- 5.21	- 1.14	- 2.10	+ 2.48	- 10.95
1923....	+ 10.76	+ 2.29	+ 11.28	- 2.88	- .37	- .65	- .60	+ 1.80	+ 2.45	+ 3.45	- 5.79	+ 15.01
1924....	- 7.04	+ .26	- 4.68	+ 4.92	- 2.27	- 4.92	- .32	- 2.01	- 3.83	+ 7.67	- 2.05	- 8.80
1925....	+ .19	- 6.73	+ 12.27	- .03	- .40	+ .97	- 3.82	+ 5.17	- 2.27	- 5.27	- 3.73	- 11.46
1926....	- 6.96	- 4.53	- 12.29	- 1.80	- 3.57	+ .19	- 5.16	- 1.12	- 2.72	- 1.37	- .14	+ .06
1927....	+ 2.92	- 5.85	- 6.28	+ 3.60	- 4.54	- 2.56	+ 1.45	- 2.10	- .51	- 3.97	- 3.56	+ 2.64
1928....	- 3.47	- 2.84	- 6.74	- 6.74	- 1.69	- 3.76	+ 2.67	- 4.23	+ 3.79	+ .16	- 3.94	- .86
1929....	+ 5.18	+ 10.43	+ 5.59	- 2.28	- 3.36	- 3.64	- 3.95	- 6.36	- 5.64	- 3.67	+ 1.16	+ 7.63
1930....	+ 1.56	+ 2.95	+ 2.75	+ 14.79	+ 2.64	+ 10.09	- 1.99	+ 17.33	+ 4.51	- 1.66	+ 2.52	- 8.50
Means..	10.36	8.68	12.55	13.67	8.10	6.20	8.89	11.48	7.30	7.06	12.14	12.26

Annual—118.69

PAAUHAU STATION

Data—Rainfall Departures

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	— 1.89	— 3.66	— .35	— .83	— .28	— .15	— .74	— .74	— 7.46	— .97	— 2.29	— 1.68
1906....	— 6.03	— 5.15	— 5.85	— .59	— 1.78	— 1.56	— 2.70	— 3.36	— 2.26	— 1.91	— 2.08	— 7.25
1907....	— 3.97	— 3.62	— 1.58	— 1.40	— 2.85	— .55	— 4.51	— 12.68	— 3.95	— 3.43	— 4.34	— 6.31
1908....	— 3.86	— 1.48	— 1.16	— 4.28	— 2.90	— 1.31	— 1.34	— .30	— 1.46	— .12	— .53	— 1.84
1909....	— 2.83	— 1.62	— 7.56	— 6.14	— 1.05	— .81	— .16	— 4.84	— 1.85	— 1.13	— 5.49	— 1.06
1910....	— 3.25	— .09	— 2.83	— 1.81	— 2.39	— 4.02	— .54	— .54	— 3.05	— 2.47	— .53	— 7.19
1911....	— 3.59	— 12.53	— .38	— .29	— 2.95	— 3.50	— 1.40	— 1.37	— 3.96	— .61	— 1.27	— 3.15
1912....	— 5.69	— 2.22	— .19	— 1.49	— 2.73	— 1.49	— 3.64	— 3.64	— .40	— 1.09	— 1.30	— 4.36
1913....	— 4.93	— 3.07	— 6.07	— 1.97	— 1.80	— .03	— 2.90	— 2.14	— .50	— 2.83	— 4.86	— 7.45
1914....	— 5.72	— 2.72	— 4.34	— .93	— 19.48	— 3.59	— 15.29	— 20.16	— 5.32	— .99	— 8.29	— 1.17
1915....	— 4.01	— 2.27	— 4.96	— 3.43	— 2.27	— 2.03	— 1.49	— 5.41	— .44	— 2.16	— 3.30	— 2.57
1916....	— 5.11	— 5.16	— 1.19	— 1.61	— 6.28	— .61	— 2.15	— 2.55	— 1.88	— 1.65	— 4.59	— 3.50
1917....	— 4.00	— 2.72	— 5.77	— 7.07	— 4.23	— 1.37	— 3.40	— 5.68	— 3.64	— 2.29	— .07	— 4.36
1918....	— .15	— 16.61	— 5.04	— 23.00	— 12.76	— 3.90	— 3.56	— .61	— 3.04	— .66	— 1.33	— 7.09
1919....	— 1.71	— 4.85	— .23	— 5.15	— 1.75	— 2.88	— 3.15	— 2.73	— 3.50	— 2.71	— 7.40	— 2.21
1920....	— 3.55	— 4.40	— 5.34	— 5.63	— 4.72	— 2.69	— 3.08	— 2.34	— 1.16	— .21	— 4.38	— 4.23
1921....	— 8.95	— 5.27	— 1.06	— 3.44	— 4.16	— 2.76	— .19	— 2.64	— 2.36	— 1.99	— 13.41	— 5.96
1922....	— 3.60	— .82	— 8.22	— 6.20	— 3.26	— 2.58	— 3.67	— 4.15	— 4.65	— 1.89	— .10	— 7.89
1923....	— 7.15	— .99	— 4.98	— 1.12	— 1.73	— 1.06	— .66	— 4.79	— 1.19	— 5.38	— 4.47	— 9.69
1924....	— 5.19	— 2.41	— 4.53	— 1.11	— 1.28	— 1.88	— 2.23	— 2.77	— 1.74	— 2.66	— 1.18	— 6.96
1925....	— .64	— 4.99	— 3.54	— .01	— .55	— .07	— 2.02	— 3.07	— .80	— 2.34	— 4.06	— 7.49
1926....	— 4.86	— 2.91	— 4.92	— 2.15	— 2.97	— 1.31	— 2.20	— .15	— .87	— 2.26	— 1.88	— 6.24
1927....	— 5.45	— 3.11	— 4.83	— 3.58	— 3.57	— 1.61	— 3.23	— 2.17	— .08	— 1.37	— .79	— 1.69
1928....	— 1.76	— 2.42	— 2.99	— 6.15	— .22	— .05	— 2.54	— 2.24	— 1.42	— 1.74	— 2.17	— 5.19
1929....	— 6.86	— 11.33	— 4.73	— .46	— .72	— 1.37	— 1.96	— .56	— 3.22	— 2.23	— 5.19	— 12.55
1930....	— 5.45	— .51	— 1.91	— 10.78	— .08	— 4.83	— .31	— 1.50	— 2.66	— .29	— 12.33	— 5.00
Means..	6.99	6.00	7.87	8.19	4.72	2.95	4.33	5.74	3.73	3.00	8.10	8.06

Annual—69.68

PAHALA STATION
Data—Rainfall Departures

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	— 5.01	— 2.96	— 4.19	— 2.61	— 2.26	— .26	— .48	— .75	— .34	— 1.43	— 4.50	— 5.22
1906....	— 4.22	— 2.38	— 4.59	— 3.15	— 1.16	— .86	— .91	— 5.25	— 2.14	— 2.88	— 9.27	— 1.20
1907....	— 6.48	— .51	— 2.31	— 2.53	— .55	— .57	— .35	— 9.66	— 5.50	— 4.73	— 4.18	— 5.67
1908....	— 4.66	— 2.63	— 3.89	— 1.49	— 2.26	— 1.07	— 1.37	— 2.82	— 1.00	— 2.54	— 3.72	— 5.32
1909....	— 5.50	— .21	— 1.04	— .54	— .80	— .82	— .73	— 3.00	— 1.10	— 3.02	— 4.42	— 6.57
1910....	— .80	— .12	— 5.27	— 3.25	— 1.68	— .44	— .81	— 2.86	— .52	— 2.92	— 2.47	— 3.62
1911....	— 3.18	— 5.01	— 6.05	— 1.80	— 4.41	— .97	— .59	— .87	— .24	— .02	— 4.76	— 2.56
1912....	— 5.41	— .11	— 4.72	— 2.93	— 1.84	— .32	— .14	— 1.08	— 1.94	— 1.89	— 5.05	— 4.59
1913....	— .97	— .52	— 5.18	— 3.44	— 5.41	— 2.03	— 1.16	— 1.12	— 1.69	— .99	— 6.17	— 4.02
1914....	— 1.40	— 2.70	— 1.85	— 2.15	— .66	— 1.52	— 6.45	— 2.98	— 1.41	— 3.11	— .55	— 3.72
1915....	— 5.71	— 2.47	— 3.77	— 2.49	— 1.43	— 1.53	— 2.12	— 1.10	— .34	— 3.29	— 27.28	— 7.64
1916....	— 12.34	— 3.02	— 8.24	— .31	— 1.29	— 1.04	— 1.35	— 2.18	— .85	— 1.99	— 3.70	— 12.79
1917....	— 4.75	— 3.04	— 13.18	— 3.79	— 6.66	— .49	— .83	— 2.65	— 1.71	— .17	— 4.58	— 2.69
1918....	— 11.24	— 17.62	— 5.24	— 5.54	— 1.11	— 1.28	— 2.56	— .51	— .99	— 2.61	— 5.58	— 5.39
1919....	— 5.14	— 4.08	— 1.99	— 3.27	— .57	— .25	— .04	— 1.45	— .18	— 1.08	— .94	— 2.64
1920....	— 2.25	— 2.57	— 1.15	— 1.84	— 1.85	— .12	— .61	— 1.27	— 1.81	— .22	— 4.18	— 5.60
1921....	— 10.79	— 1.45	— 2.69	— 2.49	— 1.37	— .97	— .78	— 1.83	— 1.86	— 3.48	— 3.83	— 3.35
1922....	— .91	— 1.83	— 2.21	— 1.77	— 1.86	— .23	— 1.08	— 2.19	— .20	— 2.03	— 2.32	— 2.77
1923....	— 13.78	— 9.04	— 5.49	— 13.75	— 1.17	— .65	— .80	— .17	— 3.32	— 3.69	— 4.09	— 4.26
1924....	— 5.51	— 3.41	— 5.15	— 12.23	— .85	— 1.16	— .25	— 2.12	— .65	— 3.87	— 1.33	— 1.58
1925....	— .95	— 2.11	— .20	— 3.16	— .98	— .04	— .80	— 1.68	— 1.60	— .09	— 3.81	— 5.41
1926....	— 2.49	— 3.67	— 5.09	— 2.00	— .76	— 1.28	— .68	— 5.05	— 6.20	— 3.05	— 3.98	— 2.32
1927....	— 4.40	— 3.84	— 2.78	— 3.71	— 2.10	— .61	— 1.12	— 1.67	— 1.59	— 2.68	— 4.35	— 34.71
1928....	— 5.50	— 3.30	— 4.90	— 2.19	— .07	— 1.88	— .31	— 2.50	— .74	— 1.10	— 3.74	— 4.22
1929....	— .51	— 1.69	— 3.67	— 2.16	— 1.01	— .60	— 1.24	— 1.98	— .74	— .30	— 11.40	— .39
1930....	— 2.17	— 2.89	— 3.12	— 2.13	— 1.74	— .67	— .49	— 4.13	— 2.51	— 2.11	— .99	— 5.64
Means..	5.82	4.10	5.78	3.54	2.30	1.07	1.37	3.00	2.40	3.86	5.21	5.81
Annual—44.26												

PAPAIKOU STATION

Data—Average Monthly Precipitation

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	-14.04	-2.64	-10.77	-8.58	-2.41	-	1.82	+.52	+9.57	-	+17.39	-3.08
1906....	-10.26	-8.56	-16.21	-6.42	-1.58	3.37	1.00	9.00	-5.23	6.23	-.15	+.47
1907....	-8.49	+6.56	-1.64	-10.49	-4.42	3.90	3.04	+27.90	+23.01	6.39	-5.36	-12.94
1908....	-4.76	+15.08	-11.88	-6.14	+.72	-.84	1.70	-.79	+7.01	3.95	-9.32	-.77
1909....	-7.01	+1.45	+19.17	-5.35	+3.71	-.22	5.31	-9.18	-3.67	-.96	-13.95	+8.39
1910....	+10.25	-6.63	+2.02	-3.00	+5.11	4.13	1.02	2.25	-7.35	3.11	-3.09	-.97
1911....	+5.47	+6.93	-6.12	+3.68	+6.88	4.38	+.19	-5.56	+6.59	-2.35	+.97	-.95
1912....	-15.65	+7.33	-2.88	-8.54	-3.11	+.99	5.38	-6.63	-6.62	10.61	1.37	+2.05
1913....	+20.10	-2.02	-8.88	-1.77	-2.50	+.87	-5.62	-6.45	-8.25	8.46	9.28	5.48
1914....	-5.65	-6.82	-7.01	-6.11	+20.08	18.63	18.83	+32.07	-24.20	1.40	2.03	-3.40
1915....	-11.07	+3.33	-15.32	+14.75	-7.94	2.55	-.09	-10.03	+6.56	8.75	+33.39	+3.04
1916....	-2.57	+8.67	-3.61	-.93	+18.50	4.96	1.19	7.40	+1.47	+.72	+6.50	+26.28
1917....	+7.67	-6.71	+9.72	+1.13	-4.23	-.76	-3.74	-12.49	-10.28	-6.84	+4.68	-10.23
1918....	+10.51	+29.85	+20.46	+18.85	+11.86	1.96	21.18	1.43	5.12	-.98	5.54	+9.73
1919....	-9.71	-2.99	-2.07	-10.79	-4.84	3.89	-3.11	2.40	-1.66	4.43	-6.23	-13.16
1920....	-10.82	-5.06	+17.23	-8.79	-10.34	5.57	2.47	7.84	+.19	7.09	-7.11	-4.07
1921....	+47.26	-5.36	-13.68	-3.17	-8.09	7.44	3.15	-5.35	-6.81	5.29	+16.52	+12.12
1922....	+15.34	+18.25	+50.31	+1.54	-1.13	1.13	-5.81	-4.63	-6.39	+.94	+8.48	+22.28
1923....	+42.52	-2.52	+16.44	+17.00	+2.30	3.84	1.77	+.60	+10.36	13.47	-7.97	-14.44
1924....	-13.15	-2.17	+10.88	+17.76	-2.48	6.30	4.66	1.12	4.13	7.76	-7.36	-17.79
1925....	-2.50	-8.76	+15.28	-2.06	+2.73	1.38	9.28	1.10	-2.23	5.78	-13.60	-3.15
1926....	-13.06	-4.69	-17.71	-15.10	-4.69	6.51	8.25	+.97	-4.85	-.77	-3.72	+30.06
1927....	-3.71	-7.11	-1.44	-6.27	-2.08	4.60	1.07	-2.53	-2.32	5.3	-11.36	+7.88
1928....	-8.16	-5.77	-14.15	-9.93	-2.29	3.34	2.77	-7.22	-3.42	+.53	-	-
1929....	-7.50	+4.50	+.87	-3.88	-8.61	7.69	+.78	-7.98	-10.61	8.20	-6.65	-4.52
Means..	16.62	11.25	19.42	17.15	12.45	10.61	13.45	16.60	14.82	12.90	18.60	19.00

Annual—182.87

STATION PEPEKEO

Data—Rainfall Departures

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1905....	- 8.01	- 2.19	- 4.48	- 4.91	- .24	- .63	+ .5	+ 1.33	+ 2.96	- .13	+ 11.84	- 2.96
1906....	- 7.91	- 6.30	- 7.66	- 5.65	- .73	- .73	- .29	+ 6.13	- 3.20	- 5.78	+ 3.08	- .30
1907....	- 6.51	+ 4.74	- .25	- 5.58	- 3.24	+ 1.67	+ .46	+ 17.01	+ 13.43	+ 5.08	- 2.60	- 8.79
1908....	- 5.35	+ 14.84	- 4.97	+ 2.30	- 2.96	- 2.08	- 3.43	- 2.93	+ 1.41	+ .64	- 3.13	+ .08
1909....	- 5.26	- 1.92	+ 19.11	+ .57	+ 2.27	- 1.75	+ 2.77	- 5.46	- 2.26	- 3.72	- 9.77	+ 5.24
1910....	+ 7.34	+ 3.20	+ 2.25	+ 5.36	+ .70	+ 3.71	+ 1.63	+ 2.29	- 6.88	- 1.79	- 2.34	+ 3.18
1911....	+ 2.90	+ 4.45	+ .15	+ 5.36	+ 7.76	+ 3.32	- .95	+ 3.97	+ 3.57	- .99	- .67	- 4.23
1912....	- 11.49	+ 2.01	+ .9	+ 3.98	- 1.60	+ 1.42	- 4.20	- 4.13	- 5.77	+ 6.30	+ .23	+ 3.34
1913....	+ 19.42	- 2.37	- 5.52	- 2.24	- .85	+ .47	- 3.30	- 4.73	- 6.04	- 4.15	+ 7.08	- 4.39
1914....	- 3.96	- 3.18	- 2.27	- 3.72	+ 13.69	+ 8.53	+ 9.72	+ 18.45	+ 16.82	- 1.42	+ 2.79	- 3.47
1915....	- 8.46	- .87	- 8.92	+ 9.26	- 5.33	+ 3.32	- .35	- 6.09	- 4.07	+ 3.69	+ 21.94	+ 1.17
1916....	- 1.38	- 6.89	- 1.65	+ .24	- 9.71	+ 1.42	- 1.73	+ 1.40	+ 1.29	+ 2.46	+ .14	+ 14.24
1917....	+ 1.60	- 4.06	+ 8.80	+ .76	- .10	+ .44	- 3.30	- 7.24	+ 7.37	- 6.75	+ 2.24	- 6.23
1918....	+ 8.36	+ 18.70	+ 12.38	+ 11.07	+ .47	+ 3.05	+ 11.64	- 1.73	- 5.18	- 1.27	- 2.60	+ 1.01
1919....	- 7.81	- 1.84	- 1.20	- 5.99	- 3.63	- 2.18	- 3.03	- 2.15	- 4.46	- .64	- 7.28	- 10.27
1920....	- 6.96	- 3.92	+ 12.11	- 5.80	- 7.37	- 3.90	- 2.55	- 4.77	+ 1.03	+ 12.00	- 5.74	- 2.16
1921....	+ 20.84	- 2.98	- 5.90	- 1.67	- 4.45	- 3.14	- .66	- 2.02	- 5.44	+ 2.97	+ 8.00	+ 2.69
1922....	+ 10.93	+ 9.58	+ 23.21	+ .79	- 1.21	- 5.08	- 2.88	- 4.20	- 7.02	- 2.68	- 5.82	- 9.93
1923....	+ 30.92	- .53	+ 12.05	+ 10.65	- .16	+ .69	+ 3.00	+ .54	+ 6.62	+ 4.79	- 6.79	+ 13.20
1924....	- 8.24	- 1.05	- 3.02	+ 6.37	- 1.65	- 4.11	+ 2.87	- .94	- 3.07	+ 7.30	- 6.47	- 10.23
1925....	- .96	- 5.86	+ 14.04	- 2.76	+ 2.81	+ .49	- 4.89	+ 1.10	- 2.71	- 3.54	- 2.10	- 12.69
1926....	- 8.16	- 2.13	- 9.45	- 8.18	- 2.69	- 4.66	- 4.35	+ 3.91	- 2.16	- 3.74	- 7.66	- .75
1927....	+ .55	- 5.11	+ 7.59	- .92	+ 2.10	- 2.06	- 2.41	- .46	- .28	- .98	- .53	+ 28.50
1928....	- 6.13	- 3.06	- 7.85	- 6.90	+ 1.50	- 1.70	+ 2.21	- 3.47	+ 2.00	+ 2.34	- 6.92	+ 8.22
1929....	- .94	+ 5.68	- .55	- 1.31	+ 4.85	- 3.97	+ 5.16	- 3.23	- 4.41	+ 6.22	- 1.86	+ 4.81
1930....	- 5.19	- 2.48	+ 2.33	+ 14.91	+ .14	+ 7.49	- 2.85	+ 5.36	+ 1.78	- 2.79	+ 3.22	- 9.26
Means..	12.44	8.07	11.66	11.91	8.59	7.39	9.30	11.30	11.33	9.62	12.80	13.83

Annual—128.24

STATION HANA
Data—Rainfall Departures

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1907....	....	....	....	....	1.97	3.92	.20	12.42	5.88	2.43	4.87	7.20
1908....	— 6.24	+ 4.31	— 2.54	— 4.21	+ 3.65	+ 1.03	.54	+ .86	— 1.82	— 2.77	+ 2.71	— 5.23
1909....	— 4.67	+ 1.05	+ 16.60	+ 5.15	— .45	+ 2.25	.79	+ 2.91	— 2.05	— .89	— 4.60	+ 2.46
1910....	+ 4.65	— 1.03	— 2.76	— 5.03	+ .03	+ 1.37	.95	+ 8.99	— 1.33	— 1.10	— 3.46	+ 22.35
1911....	+ 1.28	+ 4.24	— 1.49	— 3.92	+ 1.93	+ .41	— 1.73	+ .60	+ 5.34	— 1.88	— 3.55	— 5.42
1912....	— 7.72	— 1.34	— 3.36	— 3.82	— .58	+ 1.58	— 1.65	+ 2.45	— 3.40	+ .83	— 3.20	— .60
1913....	— 1.76	— 1.96	— 5.62	— 4.43	+ 2.72	+ .37	— 1.18	— .31	— 3.31	+ .10	+ 1.67	— 2.62
1914....	— 2.67	+ 3.65	+ 12.88	+ 5.49	+ 9.51	+ 1.45	— 1.03	+ .50	+ 21.60	— 1.20	— 60	+ 8.38
1915....	— 6.80	+ 4.11	— 6.76	+ 26.42	— 2.55	— .12	— .64	— 1.72	— 2.62	+ .84	+ 13.38	+ 3.23
1916....	+ 16.11	— 2.38	+ 5.73	+ 1.38	— 1.22	+ 1.33	+ .84	....	....	+ 1.11	— .78	+ 1.50
1917....	— 4.01	— .42	— 3.89	— .55	— .69	— 2.28	— .35	— 1.68	— 3.15	+ 2.63	— 2.38	— 4.60
1918....	+ 1.58	+ 3.14	+ 5.73	+ 18.18	+ 1.69	— .69	+ 1.20	+ 1.73	— 1.95	— 1.56	— 1.33	— 1.01
1919....	— 5.32	— 2.89	— 4.56	— 6.61	— .63	— .40	+ .90	— .44	— .52	— .06	— 3.98	— 7.50
1920....	— 3.61	— 3.23	+ 12.74	— 7.95	— 3.05	— 1.30	— .63	— 1.13	— 1.96	+ 1.03	— 1.24	+ .59
1921....	+ 7.19	— 3.92	— 2.00	— 4.56	— .79	— 1.21	+ 2.00	— 1.66	— 1.13	— 1.83	+ 3.19	+ .86
1922....	+ 19.09	— .26	— 2.11	— 7.42	— 1.78	— .91	— 2.56	— 2.05	— 2.03	+ 2.16	+ 2.22	— 6.67
1923....	+ 9.08	+ 1.37	— .13	+ 3.59	— 2.01	— 1.15	— 1.08	— 2.04	+ .83	+ 2.52	— 1.06	+ 6.82
1924....	— 6.75	— .76	— 4.17	+ 6.63	+ .37	— .21	+ 1.56	— 2.06	+ 2.74	+ 1.49	— 5.06	— 3.63
1925....	— 4.25	— 1.05	+ .35	— 5.12	— .95	— .01	— .64	— .63	— .57	— .54	— .17	— 2.73
1926....	— 5.78	— 2.76	— 6.14	— 5.79	— 2.50	+ 1.37	— .44	— .03	— 1.10	— .48	— 1.94	— 5.16
1927....	— 1.22	— 1.90	— 2.87	+ 7.44	— .12	— 1.12	— .72	+ .79	+ .62	— .79	— .36	+ 12.21
1928....	— 4.00	— .54	— 4.72	+ .44	— .82	— .62	+ 2.06	+ .23	— 1.64	— 1.81	— 2.81	— 1.32
1929....	— 1.02	+ 8.45	— 3.90	— 7.19	+ .18	— 1.36	+ 1.08	+ .59	— 1.70	— .75	+ 6.74	+ 5.55
1930....	+ 8.69	+ 1.40	+ 3.00	+ 2.22	+ .02	— .59	+ 1.14	— 2.76	— .90	+ .65	+ 7.10	— 4.89
Means..	8.56	5.42	7.54	9.42	4.57	3.77	4.31	5.36	5.22	4.90	6.67	9.47

Annual—75.21

TABLE J
DATA—EXTREMES OF TOTAL MONTHLY RAINFALL

HAWAII	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Hakalau	39.97	24.71	43.87	27.45	30.16	18.86	17.88	37.21	37.31	30.05	46.49	43.75
	2.29	1.23	1.54	3.61	0.23	1.77	3.69	2.91	2.56	4.00	6.18	2.91
Hilo	41.60	29.43	66.96	22.84	20.48	25.47	23.45	37.77	26.28	25.08	31.40	51.88
	0.99	1.92	1.75	2.00	1.31	2.32	4.77	2.42	2.50	2.64	4.09	1.32
Honokaa	19.00	24.32	15.99	17.88	18.66	8.32	19.45	17.85	12.06	8.15	24.79	19.47
	1.21	0.57	1.41	1.36	0.05	0.19	0.45	0.15	0.36	0.20	1.56	0.22
Kohala	15.10	10.68	11.40	18.78	12.40	10.85	12.62	18.43	8.63	5.73	13.92	14.96
	0.86	0.49	1.20	1.81	0.68	0.68	1.29	0.69	0.38	0.97	1.13	0.76
Naalehu	16.42	9.78	13.76	13.00	5.88	4.78	4.90	11.64	11.49	8.10	14.79	25.71
	0.40	0.12	0.20	0.45	0.40	0.24	0.22	0.11	0.12	1.34	0.41	0.40
Niulii	18.06	9.79	11.92	18.80	14.56	11.56	14.78	19.53	9.20	6.14	14.00	15.11
	1.01	0.40	0.96	1.97	0.48	0.76	1.82	0.87	0.33	0.91	1.11	0.44
Olaa	37.86	31.27	44.56	28.04	21.98	25.75	22.46	34.18	22.97	19.87	37.08	48.24
	1.06	1.54	2.31	1.94	1.80	2.04	4.21	3.77	3.16	3.46	3.18	3.13
Ookala	39.23	19.11	31.46	50.01	25.23	17.08	30.66	38.69	20.40	16.12	25.18	27.27
	1.67	1.94	0.26	4.08	0.09	0.98	2.69	0.77	0.59	2.95	1.23	0.80
Paauehu	15.94	22.61	16.09	31.19	24.20	7.78	19.62	25.90	9.05	8.38	20.43	20.61
	0.96	0.73	1.80	1.12	0.00	0.07	0.66	0.06	0.09	0.17	0.70	0.17
Paauiio	25.57	25.16	23.51	43.69	28.14	16.48	26.60	33.10	14.15	8.72	23.93	31.29
	0.76	1.22	2.03	2.28	0.03	0.20	1.17	0.21	0.10	0.58	0.50	0.14
Pahala	19.60	21.72	18.96	17.29	8.96	3.10	7.82	12.66	8.60	8.59	32.49	40.52
	0.11	0.02	0.51	0.10	0.04	0.00	0.00	0.00	0.26	0.17	0.16	0.14
Papaikou	63.88	41.10	69.73	36.00	32.53	29.24	34.63	48.67	39.02	23.51	51.99	49.06
	0.97	2.49	1.71	2.05	2.11	2.92	4.17	4.11	4.21	4.44	4.65	1.21
Pepeekeo	33.28	26.77	34.87	26.82	22.28	15.92	20.94	29.75	28.15	21.62	34.74	42.33
	0.95	1.18	2.21	3.73	1.22	2.31	4.41	4.06	3.96	2.87	3.03	1.14
MAUI												
Hana	27.65	13.87	24.14	35.84	14.08	7.69	6.37	17.78	26.82	7.53	20.05	31.82
	0.84	1.50	0.78	1.47	1.52	1.10	1.75	2.45	1.82	2.13	1.61	1.97

TABLE K
STATION PEPEEKEO
DATA—SEASONAL RAINFALL

Year	Winter	Spring	Summer	Fall
1905.....	17.49	22.11	36.27	45.00
06.....	10.30	20.78	34.57	33.25
07.....	30.15	20.74	62.83	35.30
08.....	36.69	25.15	26.98	33.84
09.....	44.00	28.98	26.98	28.00
10.....	38.56	26.94	25.71	35.39
11.....	39.67	39.12	30.58	30.36
12.....	22.78	31.69	17.83	46.12
13.....	43.70	25.27	17.86	34.79
14.....	22.76	46.28	76.92	34.15
15.....	13.92	35.14	21.42	63.05
16.....	22.25	39.26	32.89	53.09
17.....	38.51	28.99	14.02	25.51
18.....	71.61	42.48	36.66	33.39
19.....	21.32	16.09	22.29	18.06
20.....	33.40	10.82	25.64	40.35
21.....	44.13	18.63	23.81	49.91
22.....	75.89	22.39	31.87	29.46
23.....	74.61	39.07	42.09	47.45
24.....	19.86	28.50	30.79	26.85
25.....	39.39	28.43	30.85	16.92
26.....	12.43	12.36	29.33	24.10
27.....	35.20	27.01	33.60	63.24
28.....	15.13	20.79	32.67	39.89
29.....	36.36	17.76	29.45	32.98
30.....	26.88	50.43	36.22	27.42
Means.....	32.17	27.89	31.93	36.25
Extremes	75.89	50.43	76.92	63.24
	12.43	10.82	14.02	16.92

SUNSHINE DATA

While there are some temperature and rainfall data, there are practically no data on sunshine. So far as we know, only three plantations have been keeping sunshine data for the last few years. The data from two plantations together with the complete data of the U. S. Weather Bureau at Honolulu are given in Table L.

Ewa Plantation Co.

Relationship between the Purity of Crusher Juice this Season and the Number of Clear Days in Nov. of the Previous Year.

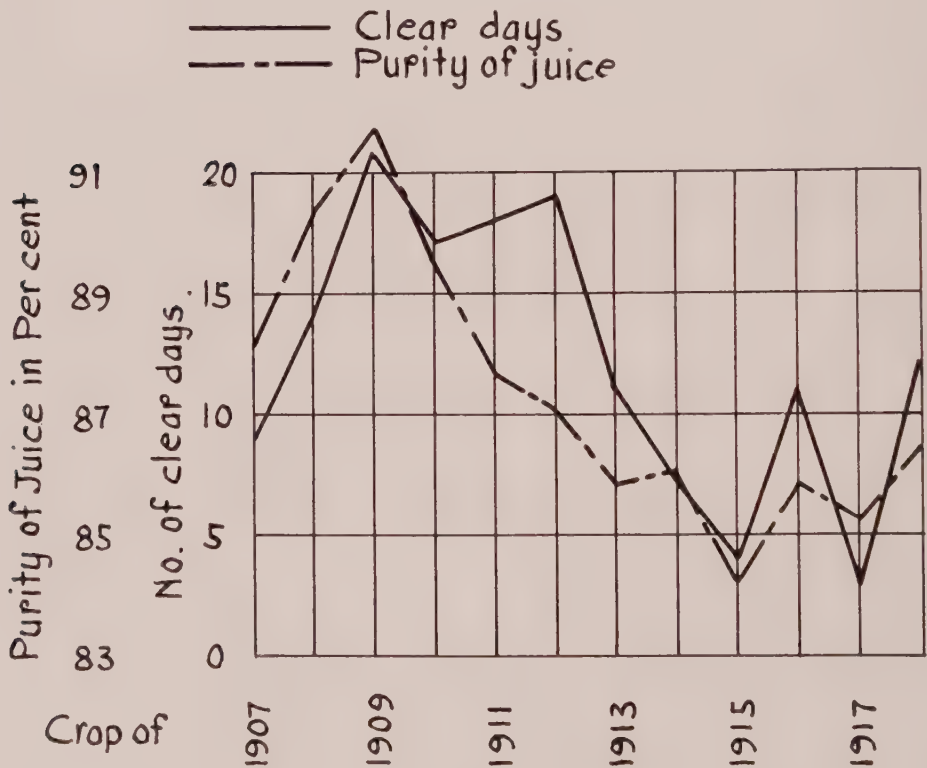


Fig. 9

Seeing that sugar cane is mainly a storehouse of carbohydrates, the relation of hours of sunshine to sucrose formation must indeed be great. In fact a study of the relation of juice quality to the number of bright, clear days at Ewa indicate quite definitely that even in these islands the amount of sunshine is far from being overabundant—that the variations in the quality of juice may be appreciably influ-

enced by the variation in the amount of sunlight from year to year (Fig. 9). We believe that the amount of sunshine plays a role of great importance in the growth and development of the sugar cane plant, and bright, clear days, and a great amount of sunshine are essential to high production of cane and sugar.

Some plantations keep monthly records of the number of clear, and cloudy days. These records, even though very incomplete, are of great help in studying cane production and juice quality. In places where the observer has been the same person over a number of years, the records will be of great value in a comparative study of the amount of sunshine from year to year. Where observers have changed, personal errors may have crept in.

TABLE I
STATION HONOLULU
DATA—ACTUAL HOURS OF SUNSHINE

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1904									281	203	165	158	
05	184	229	222	243	322	304	288	273	261	268	224	226	3044
06	246	256	256	300	260	276	278	266	229	226	185	136	2914
07	127	194	120	115	243	262	248	213	204	203	158	268	2354
08	263	250	220	266	292	272	279	295	245	241	244	229	3096
09	212	192	178	204	260	230	202	269	248	223	246	156	2620
10	154	198	241	194	247	259	289	270	204	237	209	193	2696
11	147	191	231	265	264	256	234	244	195	229	219	185	2601
12	224	176	156	227	240	216	215	241	210	266	193	187	2551
13	240	242	283	292	314	293	356	346	338	315	225	271	3515
14	245	277	269	310	332	341	354	334	290	334	304	294	3685
15	316	208	316	283	308	285	279	255	236	205	100	105	2896
16	84	155	212	255	249	215	255	235	206	194	143	126	2329
17	164	158	127	188	208	238	262	270	244	210	182	174	2425
18	169	168	219	162	254	264	267	279	280	264	226	241	2793
19	257	243	272	215	284	306	334	328	296	279	252	227	3293
20	235	255	207	233	184	269	278	306	274	267	197	211	2917
21	126	233	224	239	214	231	233	268	228	240	179	173	2588
22	149	149	235	237	236	191	245	236	216	227	214	244	2579
23	122	176	170	221	261	249	217	209	215	227	206	127	2399
24	255	186	226	170	247	214	249	280	238	199	174	211	2648
25	230	201	217	160	180	236	278	320	261	237	188	181	2690
26	207	206	217	238	254	244	287	282	276	239	229	175	2855
27	212	212	160	198	238	284	248	288	242	238	174	142	2635
28	214	227	229	236	236	270	272	282	287	265	184	241	2942
Means													
1905-28	199	211	216	224	256	258	268	274	245	246	203	195	2795
1929	240	205	253	245	251	265	297	292	272	267	177	182	2946
1930	212	238	223	248	301	242	288	254	255	272	247	241	3021
1931	242	229	238	251	241								

Annual total hours possible=4436.

“ “ “ obtained=2795 or 63%.

STATION OAHU SUGAR COMPANY
DATA—HOURS OF SUNSHINE

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Total	342	320	373	379	407	402	411	398	367	361	334	338
Possible												
1926							284	294	285	264	264	240
27	242	224	199	233	232	251	236	261	233	239	154	110
28	167	194	234	252	231	332	351	347	311	267	208	264
29	256	186	232	259	228	279	274	272	258	267	192	219
30	225	215	214	232	317	258	297	230	226	271	226	247
31	208	209	214	263								

HONOKAA MILL STATION
DATA—HOURS OF SUNSHINE

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1920	131	219	215	234	310	299	283	296	287	288	277	190
21	124	200	136	146	258	267	282	157	130	98	74	88
22	72	58	91	114	284	250	249	229	176	199	130	149
23	88	115	109	121	190	183	188	250	250	221	146	106
24	171	118	199	176	207	262	220	230	230	177	164	189
25	148	153	162	126	140	174	239	185	176	199	144	302
26	298	251	292	193	290	295	296	250	258	241	195	174
27	177	221	193	172	268	284	238	219	253	232	185	143
28	180	190	225	209	208	308	272	273	217	216	158	148
29	116	139	200	209	227	243	290	259	265	232	149	81
30	148	161	152	89	214	196	181	177	188	195	139	144
31	166	147	159	153								
Means												
1920-30	150	166	179	163	236	251	249	230	221	209	160	156

Sugar Prices

96° CENTRIFUGALS FOR THE PERIOD
JUNE 17 TO SEPTEMBER 14, 1931

	Date	Per Pound	Per Ton	Remarks
June	17, 1931.....	3.33¢	\$66.60	Cubas.
"	18.....	3.35	67.00	Cubas, Porto Ricos.
"	23.....	3.36	67.20	Cubas.
"	24.....	3.39	67.80	Porto Ricos, 3.38; Philippines, Cubas, 3.40.
"	25.....	3.40	68.00	Cubas, Philippines.
"	30.....	3.425	68.50	Cubas, 3.40, 3.42, 3.43, 3.45; Porto Ricos, 3.45.
July	1.....	3.47	69.40	Cubas, 3.46, 3.47, 3.48.
"	2.....	3.45	69.00	Cubas.
"	3.....	3.445	68.90	Cubas, 3.45; Philippines, 3.44.
"	6.....	3.42	68.40	Philippines.
"	8.....	3.44	68.80	Cubas.
"	10.....	3.45	69.00	Cubas, Philippines, Porto Ricos.
"	13.....	3.46	69.20	Cubas.
"	14.....	3.49	69.80	Cubas, 3.48, 3.50; Porto Ricos, 3.49, 3.50; Philippines, 3.50.
"	16.....	3.50	70.00	Porto Ricos, Cubas.
"	20.....	3.55	71.00	Cubas.
"	28.....	3.545	70.90	Cubas, 3.55; Porto Ricos, 3.54.
"	29.....	3.50	70.00	Cubas.
Aug.	5.....	3.51	70.20	Porto Ricos.
"	10.....	3.50	70.00	St. Croix.
"	17.....	3.47	69.40	Cubas.
"	21.....	3.415	68.30	Cubas, 3.41, 3.42.
"	24.....	3.39	67.80	Cubas, 3.38, 3.40; Porto Ricos, 3.40.
"	25.....	3.42	68.40	Cubas.
"	27.....	3.39	67.80	Cubas, 3.38, 3.40.
"	28.....	3.40	68.00	Porto Ricos.
"	31.....	3.38	67.60	Cubas.
Sept.	2.....	3.375	67.50	Cubas, 3.37, 3.38.
"	3.....	3.37	67.40	Philippines, Porto Ricos.
"	4.....	3.40	68.00	Cubas.
"	9.....	3.42	68.40	Cubas, Porto Ricos.
"	10.....	3.45	69.00	Cubas.
"	11.....	3.445	68.90	Cubas, 3.44, 3.45; Philippines, 3.45.
"	14.....	3.44	68.80	Cubas.

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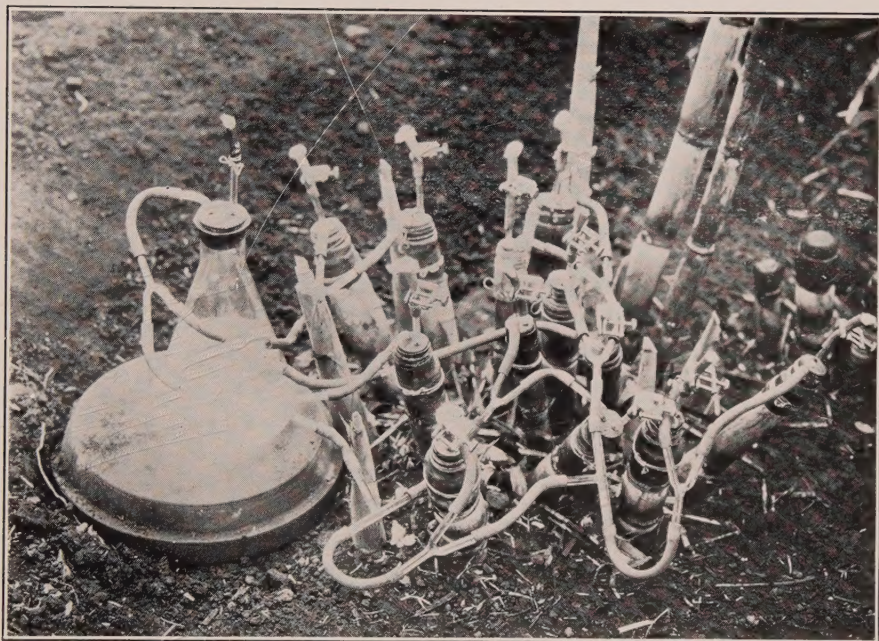
ILLUSTRATIONS APPEARING ON THE COVERS OF
VOLUME XXXV

January



Seedlings from tassels imported from Australia being propagated in
quarantine at Mapulehu, Molokai.

October



Method of collecting root pressure liquids from the cane plant for chemical analyses.

